DECEMBER, 1958
Vol. 12, No. 12

FT food technology

Color Study

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IN THIS ISSUE—

THE TECHNICAL ARTICLES IN BRIEF

Estimation of bacteria — *Frozen vegetables*

Resazurin reduction by microorganisms in fresh frozen vegetables. W. E. Ferguson, A. R. Yates and A. H. Jones.

The rate of reduction of resazurin dye is not necessarily proportional to the numbers of aerobic, mesophilic bacteria present in frozen vegetables. Dormancy of these microorganisms influenced the rate of reduction of the dye. Little or no difference in reduction times was found in high and low count samples when analysed immediately after removal from frozen storage. Suspensions of these samples held for 4 to 6 hours at approximately 26° C., however, showed a much faster reduction of the dye in high count samples. Some of the bacteria had apparently become active. Blanching of fresh peas produced reducing agents in the product. This was quite marked in samples initially low in bacterial numbers as shown by the earlier color change in the blanched as compared with the raw product. Vegetables held in frozen storage for 2—2½ months contained reducing agents in addition to microorganisms as evidenced by similar rates of dye reduction in sterile filtrate and unfiltered portions of these vegetables suspensions. Further tests indicated that adding ascorbic acid caused no noticeable increase in the rate of reduction. For these reasons, and because types of microorganisms vary in their ability to reduce the dye, it is concluded that the number of bacteria in frozen vegetables cannot be estimated with any reasonable degree of accuracy by this method. (See page 641).

Time-temperature tolerance — *Frozen strawberries*

Time-temperature tolerance of frozen foods. XIV. Ascorbic acid and its oxidation products as a measure of temperature history in frozen strawberries. D. G. Guadagni and S. H. Kelly.

Data are presented to show that total ascorbic acid (ASA + DHA + DKA) in frozen strawberries remains constant under a wide variety of time-temperature conditions. This permits estimation of the original ascorbic acid content of any given sample of berries regardless of temperature history. Loss in ASA can and does occur prior to processing, during slicing and sugaring, and prior to freezing as well as during frozen storage. Therefore, total ASA loss represents total damage which occurred both prior to freezing and during subsequent frozen storage. A simple procedure for estimating the equivalent time-temperature exposure of any given sample of frozen strawberries is given. (See page 645).

Radiation preservation — *Milk, milk products*

Radiation preservation of milk and milk products. VII. Storage studies on milk subjected to cobalt-60 radiation distillation procedures. J. E. Hoff, J. H. Wertheim, R. N. Roychoudhury, S. T. Leolalkar, B. E. Proctor, and S. A. Goldblith.

The concurrent radiation-distillation apparatus has been redesigned to allow for sterile sampling procedures and storage of the irradiated milk under study. Data on changes taking place during storage of sterile milk treated by this means are reported as well as studies on means of modifying these changes. (See page 648).

Packaging — *Prepackaged meat*

Factors affecting quality of prepackaged meat. IV. Microbiological studies. C. Effects of initial bacteria count, kind of meat, storage time, storage temperature, antioxidants, and antibiotics on the rate of bacterial growth in packaged meat. Frank E. Halleck, C. Olin Ball, and Elizabeth F. Stier.

Bacterial growth was not influenced by the kind of meat (beef, lamb or pork). However, the proportion of fat and lean did have an affect. Fat ground meat was apparently a better substrate than lean ground meat. Antioxidants (ascorbic acid and nordihydroguaiaretic acid) did not influence the growth of bacteria during a 14 day storage period at 40—44° F. The antibiotics, Bacitracin and Neomycin, in unpackaged meat, did not influence bacterial growth. High concentrations of Streptomycin and penicillin inhibited growth for only the first two days of storage at 40—44° F. (See page 654).

Antibiotic treatment — *Turkey meat*

Effect of antibiotic treatment on storage life of turkeys. A. A. Kraft, L. E. Elliott, and A. W. Brant.

With the current use of antibiotics, chlorine, and other sanitizing agents in poultry processing, the need exists for more critical study of the role of initial microbiological quality of the raw material. In addition, the possible application of these antimicrobial agents to small-scale processing conditions has not been determined. A study was undertaken to evaluate the effects of preservative agents on laboratory processed poultry; the present article is confined to the action of chlortetracycline and chlorine on turkey meat. Birds treated with chlortetracycline were held in the antibiotic solution in chill tanks overnight; some were given an additional dip in chlortetracycline after

DECEMBER COVER. Among the food qualities of concern to the processor and the food scientist, color is high on the list. The color cut for the December issue is by courtesy of Magnuson Engineers, Inc., San Jose, Calif., who developed the Agtron instrument shown in the cut after exhaustive studies of tomato color measurement. The color photograph was composed and taken by J. M. Cahill, Libby, McNeill and Libby, Eastern Laboratories Division, Blue Island, Illinois.

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evisceration and prior to packaging. Chlorine treatment was applied to other turkeys in separate chill tanks. Control birds were not subjected to antibiotic or chlorine. Initial bacterial counts on the flesh and skin of the turkeys were generally low, and this undoubtedly contributed to the effectiveness of the preservative agents. Chlortetracycline provided an increased storage life in the range of 7 to 14 days when used as a single dip in the chill tank. With a second dip in antibiotic solution and ice after evisceration, the keeping time of the turkeys was increased further. Chlorine produced a decrease in bacterial numbers on the skin surface during the first week of storage, but was not as effective as the antibiotic in retarding spoilage. An interesting observation concerned the inhibitory action of the skin of turkeys processed at 140° F. (60° C.). Spores of *B. cereus* var. *mycoides* were inhibited in growth by the skin of sub-scalded control birds. (See page 660).

Packaging *Prepackaged retail beef cuts*

Effect of storage conditions on the color of frozen prepackaged retail beef cuts. W. E. Townsend and L. J. Bratzler.

Processing and storage conditions, especially temperature and type of light, have a marked effect on the stability of color in prepackaged frozen retail beef cuts. Beef rib steaks, vacuum packed in transparent wrappers, were used throughout all phases of this study. Studies conducted were (a) prehandling conditions, rate of freezing at 0° F. and −20° F. on initial color degradation; (b) repeated freezing and thawing in two types of wrapping material; (c) color degradation of steaks stored under the same light intensity, but at two different temperatures; (d) display of samples under various colored filters and colored fluorescent lamps. Color was evaluated by the Munsell Spinning Disk Method and as percent metmyoglobin by use of a model DU Beckman Spectrophotometer. Prehandling conditions and rate of freezing affect initial color degradation of prepackaged frozen beef cuts. Repeated freezing and thawing in an oxygen impermeable wrapper has a marked effect on the color of prepackaged frozen beef cuts. Temperature of display of prepackaged frozen beef cuts under fluorescent lighting at the same level of illumination had an effect on color degradation. Samples stored under fluorescent lighting at 0° F. showed less discoloration than samples stored in darkness in a self-service case in which there was considerable temperature fluctuation. Wave-lengths of light between 560 mμ and 630 mμ (yellow and orange portion of the spectrum) seem to be responsible for color degradation of prepackaged frozen retatil beef cuts. (See page 663).

Military feeding *Preassembled, precooked meals*

Feeding the army of tomorrow. Virgil O. Wodicka.

Our Army may be forced to fight engagements of the type known in the past but in remote and difficult areas. At the other extreme, it may need to fight an atomic war on battlefields of Europe or Asia but with almost entirely new and unproven weapons, tactics, and techniques. In either event, supply capabilities are not likely to permit support of extensive operations with perishable foods. In the past, rations of all non-perishable foods have not been satisfactory for feeding over long periods. Present plans favor maximum use of dehydrated foods for overseas use. Foods will be supplied pre-assembled into meals to avoid sorting and handling in the field. Where field kitchens can

be used, foods will be supplied uncooked wherever advantageous for quality; where cooks and kitchens will not be available, "quick-serve" meals (chiefly dehydrated cooked foods) will be used. The latter can be prepared for serving by adding boiling water to the package and holding for not longer than 20 minutes for reconstitution. Maximum use will be made of flexible containers to reduce tare weight and use space more efficiently. Where individuals must eat as such, food will also be issued in meal form. (See page 667).

Packaging *Milk, milk products*

Effects of light on homogenized whole milk and some fortified milk products. J. J. Birdsall, L. J. Teply, and P. H. Derse.

Both fluorescent and sunlight have marked effects on the quality characteristics of milk and milk products. Milk stored in well-lighted store display cases can undergo losses in ascorbic acid, riboflavin and vitamin A when not packaged properly. Undesirable flavor changes will occur if milk is exposed to fluorescent lighting for 3 days or more. The foil laminated carton was the only package tested which was completely effective in preventing all undesirable changes in quality under fluorescent conditions. If milk is allowed to stand on the doorstep, in the sun, considerable changes in quality will take place. Riboflavin, ascorbic acid and vitamin A will be greatly decreased and undesirable flavors will appear. Prevention of these defects can be achieved by packaging the susceptible product in brown glass or foil laminated cartons. (See page 670).

Measurement *Properties of shortening*

Blending and measurement of the properties of shortening. John B. Woerfel and Robert W. Bates.

Shortening is described and defined. The different types are discussed as well as the ingredients in common use for this purpose in the United States. Characteristics of the various ingredients of raw fats and oils are mentioned. A review is given of the common control tests (in general use) which are used to measure the characteristics of shortening. Their relationship to performance is discussed. Newer control or research techniques are analyzed. These include dilatometric and rheological techniques. Data are presented showing the dilatometric values of common fats as well as shortenings intended for specific use. Blending of fats on the basis of their dilatometric values is considered. In the latter phase, the peculiarities of some fats in blends are shown. The work of Loska *et al.* with the Brabender Rheometer is reviewed. Data are presented showing rheological values on common and special types of shortening. The relationship between penetration, rheological values, and dilatometric solids is described for shortenings with widely differing characteristics. Techniques used in actually measuring the functional characteristics by means of test cakes, icings, creaming volumes, etc., are explained. (See page 674).

Assessing freshness *Fish, fish products*

A review of the value of volatile reducing substances for the chemical assessment of the freshness of fish and fish products. Lionel Farber and Peter Lerke.

Content of volatile reducing substances (VRS) in relation to organoleptic judgment for such non-pelagic, bottom fish

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as sole, flounder, dab, rockfish and California halibut, for such pelagic fish as salmon, sardines, mackerel and tuna, for whale, for the mollusc squid and for the crustacean shrimp is presented and summarized. Raw, canned, smoked and salted products have been tested. In all cases the contents of VRS correlated very well with the organoleptic tests. In contrast to these data, contents of total volatile and trimethylamine nitrogen, of steam volatile acidity, or of tetrazolium reduction all showed a variable relationship and often failed to reflect the sensory judgments. (See page 677).

Radiation preservation — *Radiation sterilized pork*

Effect of variations in curing salts on oxidative changes in radiation sterilized pork. Duane Hougham and Betty M. Watts.

Various concentrations of nitrite and nitrate were used in the cure of pork to be treated with gamma rays. Nitrite recoveries, pigment changes and oxidation of tissue fats were noted after radiation and subsequent storage at room temperature. The addition of 200 p.p.m. nitrite with no nitrate appears to be optimum for formation and retention of the cured meat pigment. Radiation converts nitrate to nitrite, but the amount of nitrite produced from this source is not sufficient to constitute a hazard. Radiation also causes loss of nitrite. Radiation produces partial oxidation of the cured meat pigment which is regenerated during subsequent storage. TBA values vary with the extent of pigment oxidation. It is postulated that ferric but not ferrous hemes catalyze the oxidation of fatty components of meat tissue. (See page 681).

Storage study — *Tray-pack fryers*

Influence of scald temperatures, chill times, and holding temperatures on the bacterial flora and shelf-life of freshly chilled, tray-packed poultry. E. O. Essary, W. E. C. Moore, C. Y. Kramer.

A large percent of ready-to-cook poultry is being marketed as freshly chilled tray-pack fryers. Different processing plants often use different scald temperatures and chill times. Temperature for short time holding of the tray-pack poultry might be different also in these plants and in retail stores if no ice is used or the ice surrounding the trays has melted. The variation in these factors raises the question as to their influence on the shelf-life of poultry. Studies have been conducted using fryers processed in the Virginia Agricultural Experiment Station Poultry Laboratory and two commercial processing plants to determine the influence of scald temperatures, length of chill time, and holding temperatures on the shelf-life of tray-pack fryers. Comparisons were also made on the shelf-life of untreated fryers with those treated with Aureomycin using different chill times and holding temperatures. In addition, bacterial counts were made from skin samples of two birds each scalded at 128° F. for 50 seconds and 138° F. for 30 seconds and held at 36° F. Bacteria from these birds were isolated and characterized when slime and "off-odors" occurred. There was little, if any, difference in the types of bacteria found on these fryers. There was significant difference in the shelf-life of fryers, both treated and untreated, chilled for different lengths of time and held at different temperatures. (See page 684).

Improvement of keeping quality — *Oat products*

Origin and prevention of undesirable flavor changes in oat products during storage. R. Heiss.

To obtain oat products free from bitter flavor, a peroxidase test is a good control method. By its use, not only customary complaints about the quality of oat products may be completely stopped, but also a proper control of the steaming and kilning processes can be established. It is recommended that a $PV_{...}$ of about 2 be attained. For some oat varieties higher $PV_{...}$'s are admissible. By varying moisture content and temperature during steaming in conjunction with a fixed peroxidase inhibition, the flavor of the oat product can be improved. The necessary harmony of flavor and aroma is also better assured. Based on the investigations reported here, suggestions have been offered for improving the design of drying-kilns for oats. Keeping qualities of oat products during storage are influenced more by the moisture content than by the reduction of the peroxidase activity by steam treatment. At 5 to 6% moisture content, organoleptic changes during 6 months' storage at 30° C. are still insignificant, but become noticeable at moisture contents of 12 to 13% and after only 6 weeks' storage. Formation of free fatty acids in steamed oats at the moisture level under consideration, can not be attributed to lipase activity. It is probably due to an autocatalytic lipolysis. Oxidative rancidity of oats oils is no problem within the storage periods examined for steamed oats. Flaked oats requiring long shelf-life have to be dried to a low moisture content and packed in vapor-tight packages. (See page 688).

Consumer test — *Canned cling peaches*

Comparison of mass panel and household consumer responses. Rose Marie Pangborn, Marion J. Simone, Sherman J. Leonard, George Garnatz.

Canned cling peaches varying in sugar content (24.2°, 27.0°, and 27.6° Brix) and/or total acidity (0.279% and 0.408% citric) were evaluated by 4 consumer populations in California and by the Kroger Foundation's Homemaker's Reference Committee distributed throughout 19 mid-western states. In the California surveys, over 2,500 people were interviewed by mass panel and household survey techniques. In addition, a comparison of methodologies, single sample rating and paired sample-preference, was made. Effects on preference of age, sex, time of day, degree of hunger at time of tasting, and frequency of consumption of peaches are presented. A total of 750 midwestern families judged the peaches on two different occasions by method of paired comparison-preference and indicated whether they would be willing to pay a 5c per can differential for the sample preferred. (See page 693).

Military feeding — *British Army*

Prepared foods for military use (British Army). H. R. Hinton.

Accelerated freeze drying, developed at the Ministry of Agriculture, Fisheries, and Food Research Establishment, Aberdeen, Scotland, has been applied successfully in the development of a wide range of products, light in weight, small in volume, that can be used in British Army feeding systems. One example is dehydrated fish fillets. The dehydrated meat bar, a staple item in the rapidly prepared meals category, has been shown to have a storage life of about 2 years in the tropics. New developments in this field have been proceeding rapidly. (See page 699).

ADMINISTRATIVE DATA AND DIRECTORY

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Spotlight on Philadelphia

Annual Meeting of IFT in Philadephia in May Taking Final Shape

FOOD SCIENCE AND TECHNOLOGY will hold the spotlight in Philadelphia May 17 through May 21, 1959. When the final abstracts of papers are in hand January 1, 1959, Mr. Carl Pratt, Drs. Obold and Sharf, and Dr. Aksel G. Olsen, IFT president for 1958-59, can heave their first sigh of relief. The last sight of relief will occur on May 22, 1959, after the heavy responsibilities of staging an annual meeting have been discharged. But it can be predicted with confidence that these labors will be rewarded. A fine meeting is shaping up.

MULTI-PHASED TECHNICAL PROGRAM PLANNED

Food research and technology have come a long, long way from the science of the ninth century when, according to John of Gaddesden, who subscribed to the doctrine of the humours: "Foods are of two kinds. Good food is that which brings about good humour, and bad food is that which brings about an evil humour." To be covered at the annual meeting in Philadelphia in May are the biochemistry, chemistry, microbiology, physics, enzymology, histology, and nutritional aspects of cereal, meat, poultry, fish, fruit and vegetable and dairy products. Nutritional aspects of food will be discussed. Both the new and the well-established processing methods will be brought under scrutiny. Engineering problems, food additives, packaging, factors in developing food standards—these and many more phases of food manufacture will have their day, or at least their half-day, at the Philadelphia gathering of IFT scientists.

"EXTRACURRICULAR" PHASES OF THE PHILADELPHIA MEETING

The only food that will be served at the special occasions of the Nineteenth Annual Meeting will be good food—the kind that brings about "good humours." Top billing should probably go to the "Pennsylvania Dutch" dinner, arrangements for which are under the charge of Hans F. Dresel. This event promises to be a first-hand experience with the gustatory delights of an earlier day. Another great event will be the traditional Awards Banquet. Full details of these and other not-to-be missed social events will appear in a later issue of FOOD TECHNOLOGY.

Drs. Obold (left) and Sharf (right) have the technical program well in hand.

Dr. Aksel G. Olsen (left) and Mr. Carl Pratt (right) will have busy schedules at the May 17–21 annual gathering of IFT in Philadelphia.

Dr. C. Olin Ball (left) and Dr. H. H. Mottern (right) will chairman sessions on heat processing and general research, respectively.

FUTURE MEETINGS FOR FOOD TECHNOLOGISTS

1958	
December 26-31	American Association for the Advancement of Science, Washington, D.C.
1959	
February 13-15	30th Fact Finding Conference, Sponsored by the Institute of American Poultry Industries, Municipal Auditorium, Kansas City, Missouri
February 26-27	7th Annual National Dairy Engineering Conference, Kellogg Center, Michigan State University, East Lansing, Michigan
March 1-5	Convention of the National Association of Frozen Food Packers, Conrad Hilton Hotel, Chicago, Illinois
March 4-6	Southeastern Conference on Better Foods, The Georgia Center for Continuing Education, University of Georgia, Athens, Georgia
May 17–21	**Nineteenth Annual Meeting of the Institute of Food Technologists, Bellevue-Stratford Hotel, Philadelphia, Pennsylvania**
1960	
May 15-19	**Twentieth Annual Meeting of the Institute of Food Technologists, Masonic Memorial Temple and Fairmont Hotel, San Francisco, California**
1961	
May 7-11	**Twenty-first Annual Meeting of the Institute of Food Technologists, Hotel Statler, New York, New York**
1962	
June 17-20	**Twenty-second Annual Meeting of the Institute of Food Technologists, Amercana Hotel, Bal Harbor, Miami Beach, Florida**

An open invitation is extended to readers of FOOD TECHNOLOGY to send in to the Editorial Office, 11606 South Hell Avenue, Chicago 43, Illinois notices of annual or national meetings of interest to food technologists.

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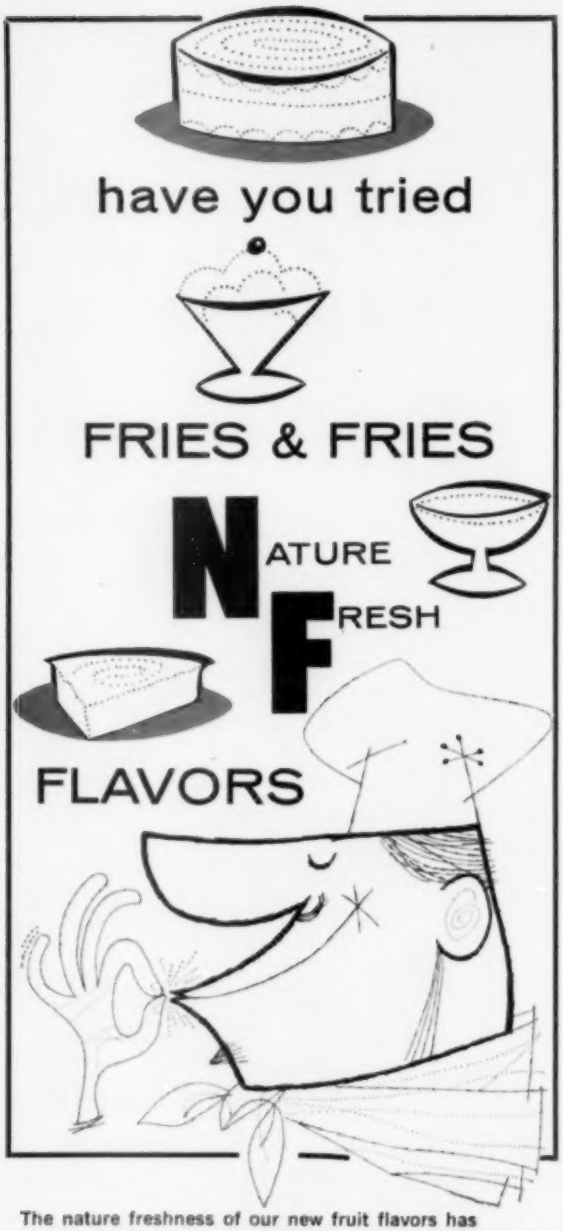

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REGIONAL NEWS

DIXIE

The Dixie Section of IFT met October 17, 1958, at the University of Georgia in Athens, Georgia, a joint meeting with our new student chapter in Athens. We cordially welcome this group of fine students into our organization. Mr. Ray B. Wakefield of Gerber Baby Foods and President-Elect of IFT presented a Gerber Scholarship Award to Mr. Gordon H. Wells, Jr., a student at the University. Mr. Wakefield followed the presentation with an address: "Things That Are Not Taught in School." He brought out that "Industry expects results." Besides the things taught in school, a person has to learn to get along with people under varied circumstances. A Food Technologist needs some liberal arts courses to help him to be more flexible in his thinking and conversation. He should be alert, able to accept responsibility, be reasonably aggressive, and have the ability and techniques to create new ideas. A Food Technologist should possess "tolerance, kindness, and a sense of humor."

A Membership Drive Committee of 8 people was appointed to make a concentrated effort to secure national members.

The Dixie Section voted to co-sponsor the Southeastern Conference on Better Foods, at the Georgia Center for Continuing Education, University of Georgia, Athens, Georgia, March 4-6, 1959.

—Cordelia Ellis

ST. LOUIS

The first meeting of the fall was held at the Gatesworth Hotel. The meeting began with a social hour that preceded dinner, which was served at seven. After dinner, Boris Miller, chairman of the St. Louis Section, called the meeting to order and a brief business session was held. A. C. Roland reported on the fine program arranged for the year. Speaker of the evening was Dr. Martin S. Peterson, editor of the IFT journals. His topic was "There's No Business Like Food Business." To highlight the rise and growth of the several branches of the food industry (meat packing, dairy products, the cereal industry, etc.) Dr. Peterson used slides reproducing old prints from nineteenth century magazines and some paintings contemporary with the era about which he was speaking. The presentation ended with a glimpse of "dining on a spaceship."

CHICAGO

Dr. William H. Stahl, manager of Chemical Research, McCormick and Co., Baltimore, Md., was the November speaker. His talk, "Instrumental Methods Used in the Analysis of Odors and Flavor,"

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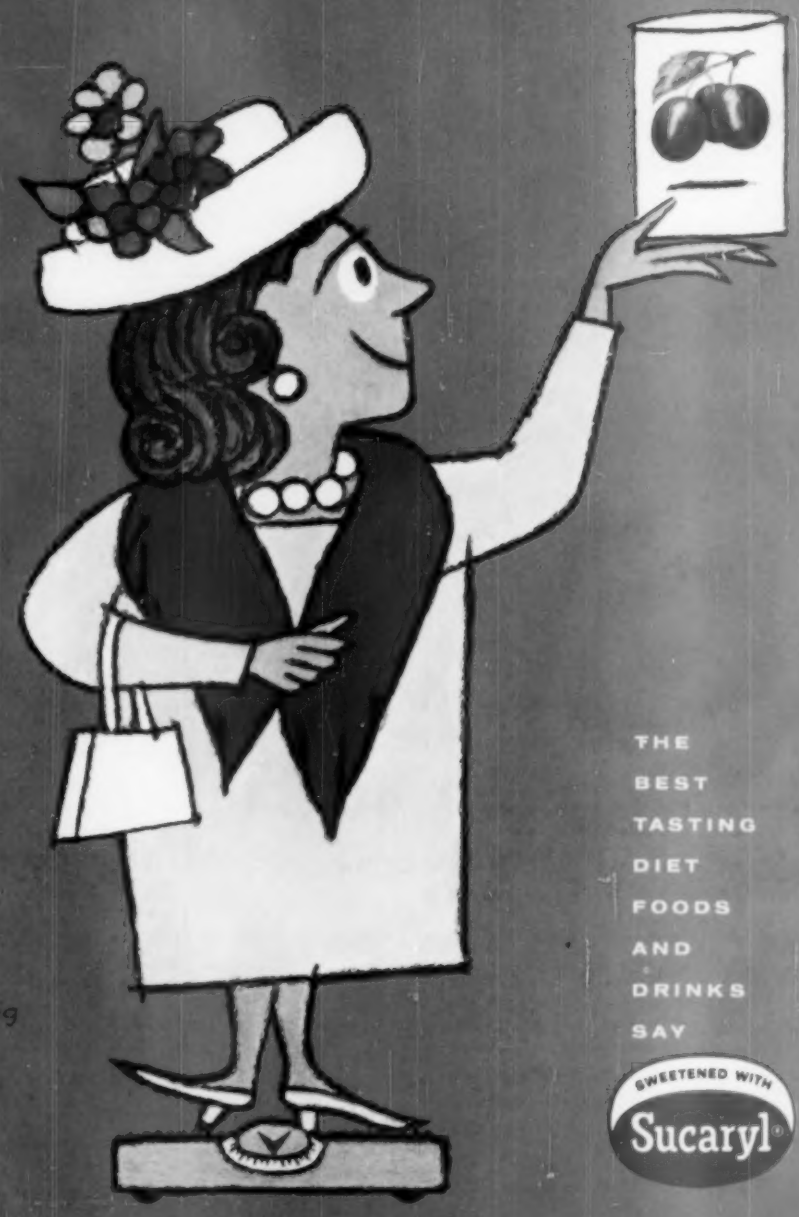

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Diet-minded shoppers respond to that little seal. They're familiar with Sucaryl itself. In both tablet and liquid form, it's the most popular by far of all non-caloric sweeteners. And now, ads like the one on the left remind them to watch for the Sucaryl seal *on your diet label.*

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For complete information about Sucaryl, send for our booklet: "Making the Most of the Dietetic Market with Sucaryl." Address Chemical Sales Division, Abbott Laboratories, North Chicago, Illinois. On request, too, we'll send you a supply of Sucaryl for your own test purposes.

Please send booklet "MAKING THE MOST OF THE DIETETIC MARKET WITH SUCARYL"

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You use Sucaryl practically anywhere you would sugar. In tablet form, to sweeten your coffee, tea or any other drink. Solution, for fruits and cereals, for cold drinks, and for cooking and baking.

Sucaryl, of course, is for anyone sensibly counting calories, and for those who for any other reason can't use sugar. Low-salt diets call for Sucaryl Calcium. Abbott Laboratories, North Chicago, Illinois and Montreal, Canada. Abbott

WEIGHT WATCHER'S JELLIED CRANBERRY RING

4 c. cranberries — 4 tbsp. Sucaryl solution
2 c. water — 2 envelopes gelatin
½ c. cold water

Combine cranberries, Sucaryl and the 2 cups water; cook 10 min., or until all the berries pop. Soften gelatin in the cold water. Add hot cranberry mixture. Stir until gelatin dissolves. Pour into an 9" ring mold. Chill until set. (10 servings)

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furnished the audience with an excellent perspective on the status of modern instruments and methodology in relation to the elusive factors in the problems of flavor. Dr. Stahl (Ph.D., Michigan State University) left the Quartermaster Corps Research Center in Natick, Massachusetts, to head up chemical research at McCormick and Co. in 1957. His discussion of isolative gas chromatography combined with mass spectrometry, infrared spectroscopy and analytical gas chromatography was based on his years of devoted study to the chemistry of flavor.

W. NEW YORK

The Section was the guest of Rich Products Corporation, Buffalo, N. Y., at a cocktails and buffet dinner meeting held in the plant on November 3. A tour of the plant was made between cocktails and dinner, and following dinner, Mr. Rex Diamond, company vice-president, addressed the group on "Whip Topping and Other Jet-Propelled Foods." Rich Products Corporation claims to be America's oldest and largest manufacturer of frozen pressure-packaged and other whippable emulsions and employs some of the fastest and most nearly completely automatic packaging machinery in the field. Mr. Diamond, formerly Chief Chemist of the late Henry Ford's George Washington Carver Laboratory, holds basic patents in the whippable emulsion field.

AUSTRALIA S.

The Southern Section advises us that the venue for the 1959 Convention has been selected—the Mayer Chalet at Warburton. The Convention will begin on Wednesday, April 28th and conclude on Friday, May 1st, 1959. For those not familiar with this area of Victoria, Warburton is situated on the upper reaches of the Yarra and approximately 50 miles from Melbourne in mountainous country. It is close to the new Upper Yarra Dam, Mt. Donna Buang and Healesville. The Chalet provides first class accommodation, and space will be available for the preparation of a first class Trade exhibition.

AUSTRALIA N.

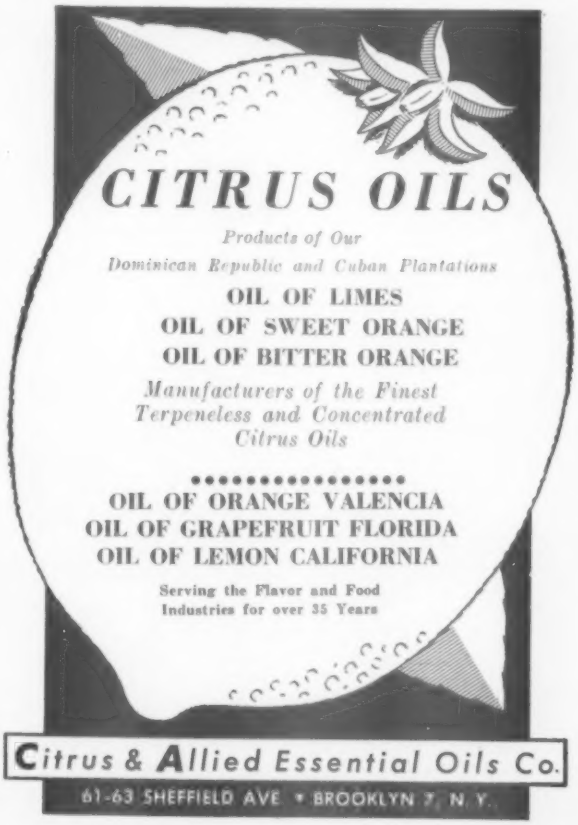
Annual general meeting. This was held on Thursday, 3rd July, at East Sydney Technical College. It was pleasing to note that 49 members and visitors were in attendance. Primary business of the evening, was the Annual Election of Office-bearers for the ensuing year. The following were declared elected:

Chairman, H. Govers; Chairman-elect, P. Muller; Secretary, P. Muller; Treasurer, J. David; Councillor, R. Bottomley; Committee, Miss A. Ross, P. Crocker, W. Hopkins, I. Hall, J. Kefford, P. Gibson, V. Lewis, J. Roche.

Following the ballot, Peter Gibson showed two films in colour on the American Shrimp (Prawn) Industry. The first of these dealt with the netting and preparation of frozen prawns for the retail trade. The second, which showed the preparation of popular and exotic prawn dishes, was sheer torture for the hungry peasants present. This second film probably accounts for the fact that several members suffered pulled muscles in their hurry to see whether the Food School could match New Orleans. No one was greatly disappointed except, perhaps, those who wanted a second helping to match the first.

SOUTHERN CALIFORNIA

SCIFTS all-day meeting October 17th brought out 138 registrants. The general subject, Food Engineering, was given consideration from many angles and the recent technological advances reported by the speakers in the various field were applicable in many industries. Both speaker and audience cooperated in keeping the prearranged schedule. SCIFTS has come to prefer a luncheon meeting with a speaker and the adjournment of the all-day meeting at the late afternoon session to the time-honored dinner meeting. Accordingly, the Nordic Suite was filled to capacity for the noon meeting where the guest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speaker was permitted to divert from the general theme of the session. Milton P. Duffy, Chief of the Bureau of Food and Drug Inspections for the State of California reviewed the activities of his department. One gained an insight into the multitude of problems with which the federal and state FDA officials must cope.

—Cora Miller

MARYLAND

The October 10th meeting of the Maryland Section of the IFT was held at the Stafford Hotel, Baltimore, Md. Dr. Richard Hall of McCormick & Co., Inc. introduced the speaker of the evening, Dr. Alex S. Malaspina of Chas. Pfizer & Co., Inc. who spoke on "Food Preservation With Antibiotics." Slides were shown illustrating the use of antibiotics in the preservation of whales.

—Leonard F. Giesecker

OHIO VALLEY

The fall meeting of the Section was held in Lancaster, Ohio, on October 10, 1958, with 58 members and their wives in attendance. The brief business meeting included outlining of plans for Food Technology—Student Day, to be held on October 18 on the Ohio State University campus. This project by the Ohio Valley Section was instituted to stimulate the interest by high school students in choosing food science and technology as a vocation.

The Anchor Hocking Glass Corporation was host for this fall meeting. Mr. Howard Waugh, of Anchor Hocking, briefly addressed the group on "Tableware and Its Place in the Ceramic Industry." The group toured the Anchor Hocking Glass Corporation tableware manufacturing facility and received a thorough explanation of the manufacture of glass and the many technical phases of this important industry.

Following the tour, the group enjoyed the hospitality of the Lancaster Country Club where an excellent dinner was served. The Reverend Charles Harrison, Assistant Director and Protestant Chaplain of the Ohio Boys' Industrial School, delivered a most thought-provoking after-dinner message, entitled "Food for Thought."

The winter meeting of the Ohio Valley Section is tentatively scheduled for January 16, 1959, in Columbus, Ohio.

NEW YORK

The first meeting of the 1958–59 season was held at the Brass Rail Restaurant, Park Avenue and 40th St., on Wednesday evening, October 15, 1958. A record turnout attended the meeting to see two of the IFT awards made by companies located in this section's geographic area and given to two students also in the section's area.

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The General Foods Award to Mr. Robert W. Dean, Rutgers University, was presented by Dr. B. T. Daubert, Associate Director, General Foods Research Center, Tarrytown, N. Y. Now working for his doctorate at Rutgers, Mr. Dean was graduated from Bates College in 1951. He was employed by Standard Brands and by General Foods prior to going to Rutgers in 1955, where he earned his Master of Science degree in Food Science in 1957. In accepting the General Foods Award, Mr. Dean briefly told the New York IFT about his research on color retention of fresh meats and on measuring meat color, which is the subject of his doctoral thesis.

The Florasynth Award to Mr. Arnold I. Epstein, also Rutgers University, was presented by Mr. Arch Payne, General Sales Manager of Florasynth Laboratories, Inc., New York. Mr. Epstein was graduated in 1955 from the University of Miami and received his Master of Science degree in Food Science in 1957. He is currently working on high temperature short time (HTST) processing of foods; he spoke to the Section about his work for his doctoral thesis, for which he is investigating enzyme regeneration in HTST processed foods.

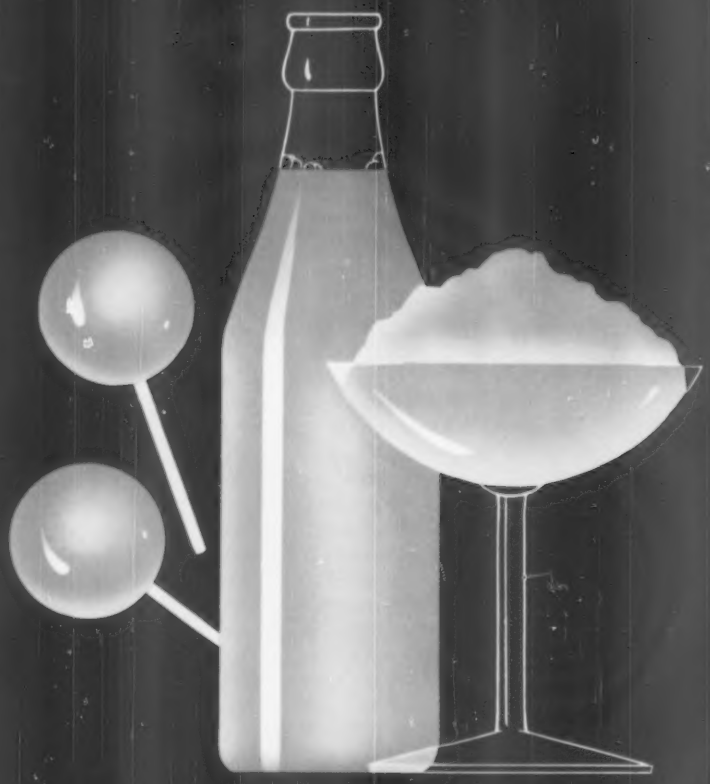
Dr. C. Olin Ball, Professor of Food Science at Rutgers, under whom the two awardees are now studying, gave an interesting talk on basic vs. applied research.

GREAT LAKES

The Fall Meeting of the Great Lakes Section was held at Benton Harbor and St. Joseph, Michigan, October 17, 1958. The morning program consisted of tours through the Research Laboratories of the Whirlpool Corporation and the Benton Harbor Plant of Michigan Fruit Canners. Following the luncheon, Col. Charles S. Lawrence, Executive Secretary of IFT, gave a delightful talk about "Affairs of the Institute of Food Technologists." The afternoon technical session included talks by Dr. Somers and Jim Bell, of the Washington, D. C. National Canners Association Laboratory. Dr. Ira Somers, Director of the Research Laboratory discussed the NCA Research Program, gave a brief history of the organization, outlined the purposes, or mission, of NCA, and then showed slides of some of the interesting activities that the NCA Research Laboratories are concerned with at the present time. Jim Bell discussed the subject of sanitation and waste disposal in food canning plants.

The election of 1959 officers of the Great Lakes Section was announced; the 1959 officers are:

Chairman-elect, F. J. Erickson, Chief Chemist, Michigan Fruit Canners; Vice-Chairman, Joseph Adams, self-employed, Food Adjunct Manufacture; Treasurer, Dr. Paul A. Wolf, Bio-Chemical Research Department, Dow Chemical Company; Secretary, Dr. I. J. Pflug, Associate Professor, Michigan State University; Executive Committee Members, K. F. Shaw, Assistant Manager of Quality Control, H. J. Heinz Co. of Canada; F. C. Witek, Chemist, Shedd-Bartush Foods, Detroit, Michigan.



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PITTSBURGH

The Year in Review. The Section met five times during the 1957-58 period with an average attendance of 45 members. The annual Ladies Night program drew 89 members and guests. The topics of discussion at the meetings were varied, ranging from Dr. Ernest Guenther's illustrated discussion of Essential Oils to Dr. Henry L. Cox's interesting talk on corn —"Gold from the Land of the Incas." The program also included an excellent talk on Research Planning by Dr. Aksel Olsen, a review of technological progress made by European Canners by George Shiffler and a paper on Mechanism of Corrosion of Tin Plate by U. S. Steel's Dr. Paul Carter. The general consensus of opinion by the Section was that the papers this past year were of excellent quality, and this is corroborated by the increase in attendance and new members.

Membership. Based on the total National Membership in August 1957, the Section gained almost 20% in new members despite the loss by transfer of four active members. This reflects the excellent work of the Membership Committee headed by V. W. Vaurio who was transferred. He was succeeded by Don Nelson.

Finances. In spite of rising costs, the Section has been able to hold the line on dues at $2.00 per year and the dinner fees to $3.35. The operating fund of the Section still shows a moderate balance with which to start the new fiscal year. The proceeds from the National Meeting held in Pittsburgh in 1957 have been invested in low interest stock with a good record of regular dividends. The proceeds from this investment are to be used in advancing the aims and objectives of the Institute, and a committee has been set up to investigate the best way to attain the expressed goal.

Special Award. For the third year, the Section has awarded a cash prize of $25.00 to a participant in the Annual Pittsburgh School Science Fair. This year's award was given to Miss Catherine Heck, a Sophomore student at Sacred Heart High School, for her investigation on "The Effect of Animal Hormones on Plant Growth."

—*Brian A. Burke*

Literature

BOOKS

FLAVOR RESEARCH AND FOOD ACCEPTANCE. Sponsored by Arthur D. Little, Inc. Reinhold Publishing Corporation, New York, N. Y. 1958. 391 pp., with index.

Recognized as highly important branches of food science, both flavor research and food acceptance are expanding with regard to applications and intensifying with respect to specialization. These trends have been encouraged by modern food manufacturers, who are well aware of the sales appeal of good flavor, and given momentum by food scientists and technologists, who have new and improved instruments to work with, and new techniques.

Few attributes gathered around the term food are as provocative of study as *flavor*. As this important new book will attest, flavor is almost incredibly complex. Dr. L. M. Beidler, studying the neural response of the taste and odor receptors by electrophysiological techniques, reports only a "meager amount of information" from this approach. The unanswered questions are many and formidable. And yet, after reading Beidler's important chapter, one gets the impression that the objectives of this work—to obtain data that will elucidate the temporal and the spatial patterns of neural responses, both gustatory and olfactory—may eventually be reached. When this is accomplished, it will be possible to organize our knowledge of flavor perception and to predict with greater assurance the behavioral responses to particular flavors. With regard to this matter of behavioral responses, Dr. Pfaffmann, in a chapter nicely calculated to follow Dr. Beidler's, states among many other interesting observations that "odor and taste stimuli appear to have more intrinsic hedonic value than do stimuli of the other senses and that these effects appear to be of basic biological origin." They can be modified, however, by internal states of the organism as well as by environmental factors through learning. Hedonic effects may vary with or be independent of the sensory effects. Cultural factors and experience will therefore continue to be of the utmost influence in determining the acceptability of foods.

Progress in laboratory flavor testing is delineated in Chapters 3 to 15. It is not surprising to find that the advances made in the subjective measurement of flavor and related food qualities are more clear-cut and easier to see than those in the realm of physiology and psychology. Sensory difference tests, the flavor profile, scoring and ranking, time intensity studies, the test environment, flavor and food acceptance methodology—these are investigative areas where the results are susceptible to the inexorable judgments of the statistician. This permits the correction of false assumptions and the attainment of what might be called "normative" accuracy of measurement. This section of the book has great reference value since it encompasses most of the lore, in essence at least, that has been gathered by the acceptance laboratories of the nation. If there is any shadow on this section, it is that the bibliographical background is somewhat sketchy.

Consumer product testing (five chapters) and specific applications of product testing in industry (seven chapters) contain some extremely interesting observations and some very useful formulas

(Continued on page 12E following technical section)

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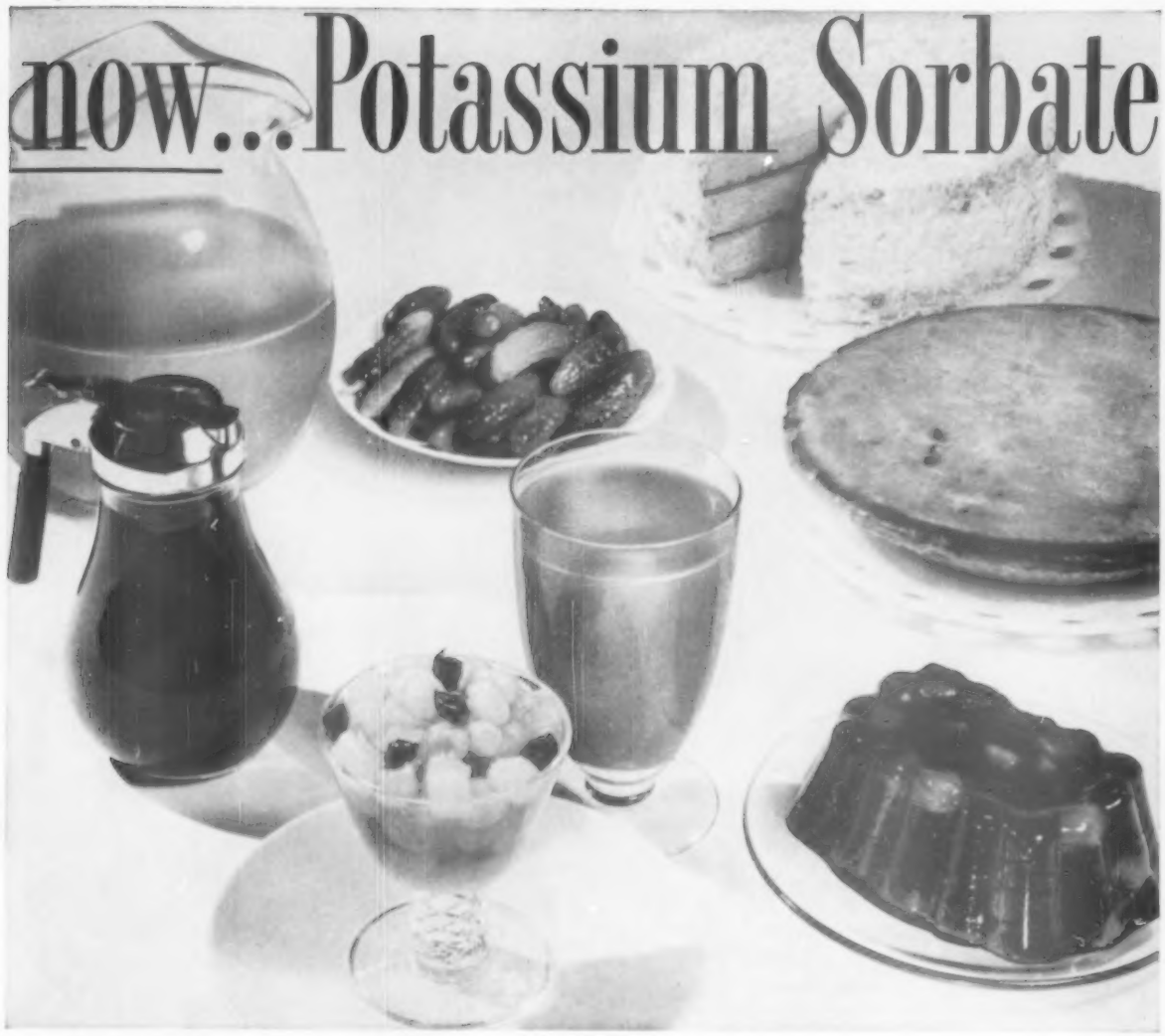

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GE-17

Resazurin Reduction by Microorganisms in Fresh Frozen Vegetables[a]

W. E. Ferguson, A. R. Yates and A. H. Jones

Bacteriology Division, Science Service, Department of Agriculture, Ottawa, Canada

(Manuscript received May 20, 1958)

PRODUCTION OF HIGH QUALITY, frozen vegetable products is dependent largely on the initial quality of the raw products, efficient blanching, and early detection and elimination of subsequent sources of contamination. A rapid, accurate objective test to estimate numbers of bacteria in these products would greatly simplify quality control. Such a test involving the reduction of resazurin or methylene blue dyes has proved efficient and has been accepted as standard procedure in testing the quality of fresh milks *(1)*. Straka and Stokes *(11)* using a modified version of the same technique claimed a degree of predictability ranging from 90 to 95% in classifying meat pies into three categories according to bacteria counts. Scott and Gillespie *(9, 10)* obtained good correlation between plate counts and resazurin reduction with egg pulp, but Johns *(6)* encountered considerable difficulty in determining end-points due to the long reduction times encountered when he applied this technique in the analysis of egg powders. Proctor and Greenlie *(8)* found relatively poor correlation between numbers of bacteria in, and resazurin reduction times on fresh and frozen eggs, meat and vegetables.

Since little or no data have been published on the use of this technique for the estimation of bacterial numbers in frozen vegetables, this present study was undertaken.

METHODS

Preparation of sample. One hundred grams of the frozen vegetables were weighed aseptically into a sterile pint jar, care being taken to obtain portions of the product from centre, sides, top and bottom of the container. One hundred ml. of sterile water were added and the mixture was shaken for 10 minutes in a horizontal mechanical shaker.

Resazurin solution. This was prepared according to A.P.H.A. Standard Methods *(1)* by adding 1 tablet of resazurin to 200 ml. of freshly boiled distilled water. The cooled solution was stored in a standard household refrigerator for no longer than 3 days before use.

Procedure. In the analyses of frozen peas, 0.5 g. of low count[b] dried milk powder were added to standard, sterile 150 x 18 mm. test tubes. These were inoculated with 10 ml. of the 1:1 dilution of the frozen product and mixed with a minimum of agitation. For frozen vegetables other than peas the milk powder was dissolved in 9 ml. of sterile water and then 1 ml. of the 1:1 dilution of product added. This latter method provided an inoculum which approximated that of Straka and Stokes *(11)* in their analyses of meat pies. One-half ml. of the resazurin solution was added to these tubes and the contents mixed by a single inversion of the tube. Tubes were then placed in wire racks in a covered 35° C. water bath and examined at 15-minute intervals for color change. Using Munsell color standards a progressive decolorization from blue to white was recorded. The end-point was considered to be that point at which all but a thin ¼ to ⅜ in. ring at the surface of the medium had turned white.

Preliminary tests using this method as compared with Straka and Stokes' *(11)* procedure with trypticase soy broth showed no advantage in the latter medium. Apparently the 1:1 dilution of the product, used as inoculum along with the added milk powder, provided sufficient nutrients for the growth of the microorganisms present.

Cultural. Colony counts were obtained by plating in duplicate suitable dilutions of the samples with Difco Plate Count Agar (Tryptone Glucose Yeast Agar). Plates were counted after 4 days incubation at approximately 26° C.

RELATIONSHIP OF PLATE COUNTS TO RESAZURIN REDUCTION TIMES

Plate counts and resazurin reduction times were obtained for approximately 500 samples of domestic, frozen vegetables. A cursory examination of these results indicated little or no correlation between plate counts and resazurin reduction times for lima beans, corn and green or yellow beans. For peas there was some indication of correlation in samples submitted by two plants (A and C) whereas samples from two other plants (B and D) showed no apparent relationship (Figure 1).

A more detailed study of results is shown in Figure 2. Regression equations are plotted and correlation coefficients (''r'' values) recorded for all samples of the four main groups of vegetables analysed. The negative ''r'' values for beans and peas, −0.47 and −0.41 respectively, are considered to show significance. The squares of these ''r'' values, 22 and 17 respectively, indicated the percentage frequency that one variable was influenced by the other. Therefore, though significance was shown, the test could not be justified for predictive purposes. Since positive ''r'' values were obtained for corn and lima beans, the resazurin reduction technique was obviously of no value for these products.

Because of the wide variations in resazurin reduction times in samples of the same product having similar bacteria counts, and the variations in samples of widely different bacteria counts having similar reduction times, it was assumed that something other than the microbial content of the samples was causing reduction of the dye. Further studies were undertaken to verify or disprove this assumption.

STUDIES OF FACTORS WHICH MIGHT INFLUENCE REDUCTION OF RESAZURIN DYE

Effect of dormancy of organisms on reduction time. It will be recognized that organisms in products held for varying periods in a hard-frozen condition may be in a dormant condition. When these products are diluted 1:1 with water the temperature of the sample rises and the microorganisms return gradually to normal metabolic activity. This return to activity is known to vary with different species of bacteria *(2, 4, 5)*. In order to determine the time required to return these microorganisms to a state approaching normal growth rates, dilutions of a number of samples were incubated at room temperature (approx. 26° C.) and records of temperature, aerobic mesophilic bacteria, and resazurin reduction time differences taken at 0-, 2-, 4-, and 6-hour periods. Results of this study are shown in Table 1. Temperatures of these diluted products were within 3° C. of incubation temperatures within a 4 hour holding period

[a] Contribution No. 460 Bacteriology Division, Science Service, Department of Agriculture, Ottawa, Canada.

[b] Less than 500 microorganisms per gram.

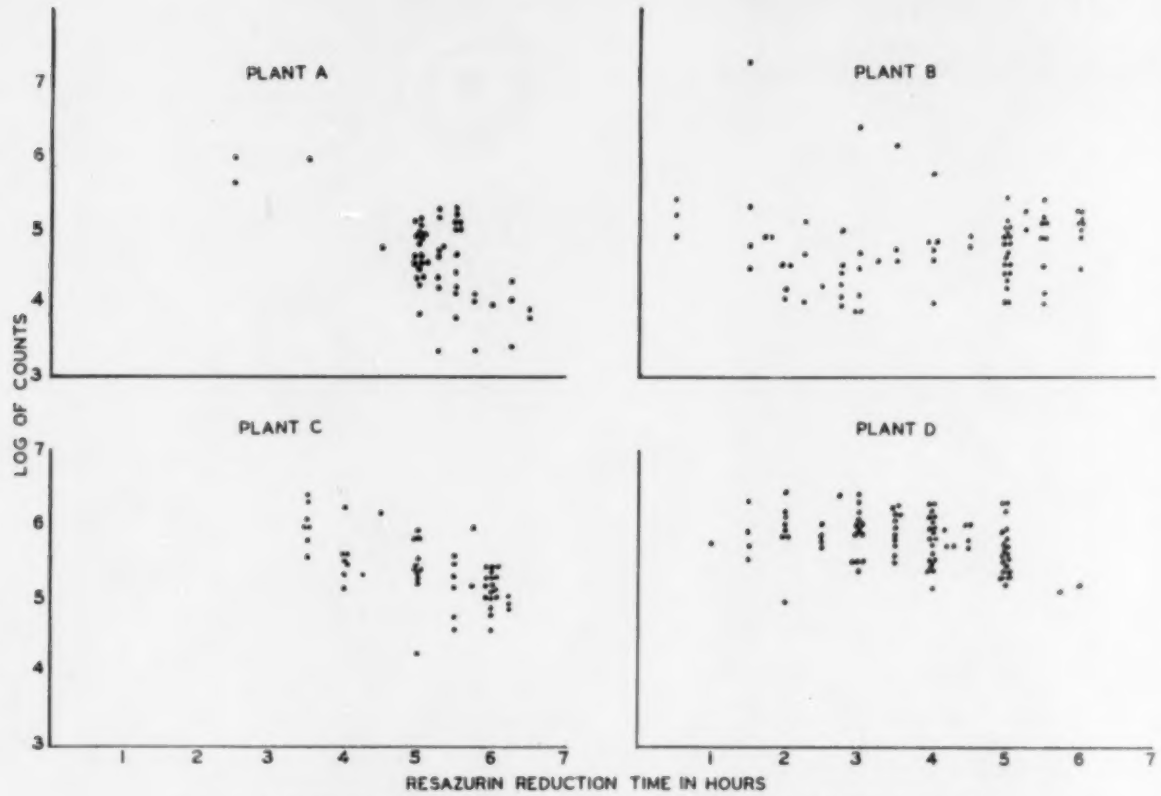

Figure 1. Relationship between bacterial content and resazurin reduction time in frozen peas.

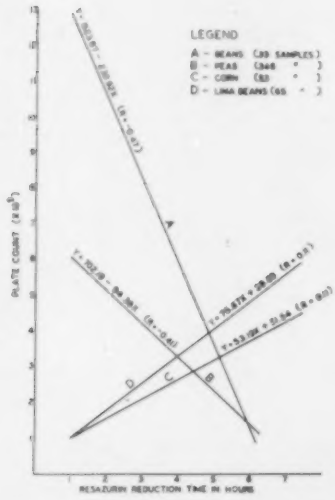

Figure 2. Relationship between bacterial content and resazurin reduction time in frozen vegetables.

but little if any change in microbial numbers was observed from plate counts made at this period. Also, in samples initially low in microbial numbers no change in reduction time of the dye was observed in tests initiated after the 0-, 2-, and 4-hour holding periods. In high count samples, however, a much shorter time was required to reduce the dye in tests begun at the 4 hour period than at 0 or 2 hours. Increased numbers of bacteria were found in all samples analyzed 6 hours after making the initial dilution indicating that some bacteria had returned to an active stage. This was further indicated by the decreased time observed in the reduction of dye. The fact that reduction times were roughly similar in high and low count samples at the initial analysis makes the practicability of the test questionable since the period of incubation required to reactivate microorganisms is known to vary between species.

Effect of blanching on dye reduction time in fresh peas. In Table 2 results are shown to illustrate the effect of blanching on the microbial content and resazurin reduction time in fresh peas. Portions of the sample were blanched for 0, 15, 30, 60 and 120 seconds. Quadruplicate portions were analysed at each period and progressive resazurin reduction changes recorded. The initial bacteria count of the raw samples was much lower than would normally be found in the raw product received at a frozen food plant. However, this test was not meant to compare resazurin reduction times in fresh and blanched samples but rather to determine if blanching produced additional reducing factors in the sample.

Little difference in numbers of microorganisms surviving the various blanch treatments was observed. The important feature of the test was that reduction of the resazurin started earlier in samples receiving the longer blanch treatments, yet the total time required to reach the end-point was the same in each instance. Blanching apparently released some constituents which either acted upon the resazurin directly or consumed some of the O_2, thereby causing an earlier action on the dye. However, no explanation can be given as to why these samples failed to show an earlier complete reduction.

Reducing substances in the product. The earlier reduction of resazurin in samples of freshly blanched as compared with unblanched peas prompted trials using sterile vegetable filtrates. These were obtained by filtering 1:1 dilutions of products which

TABLE 1

Changes in temperature, numbers of microorganisms and resazurin reduction time in analysis of frozen vegetables

Sample No.	Holding period before analysis	Temp. at time of analysis	Aerobic mesophilic bact. count (x 10^3)	Resazurin Red. time
	(hours)			*(hours)*
234	0	2° C.	78	6.50
	2	17° C.	76	7.50
	4	23° C.	95	6.50
	6	26° C.	217	5.00
235	0	3° C.	93	6.50
	2	18° C.	68	6.50
	4	24° C.	120	6.50
	6	26° C.	445	5.00
236	0	3° C.	104	6.50
	2	18° C.	102	6.50
	4	24° C.	142	6.50
	6	26° C.	398	5.00
237	0	1° C.	4,790	6.00
	2	16° C.	7,400	6.00
	4	24° C.	6,700	4.50
	6	26° C.	9,200	2.50
238	0	1° C.	7,100	6.00
	2	16.5° C.	7,900	6.00
	4	25° C.	8,800	4.00
	6	26° C.	12,800	2.00
239	0	1° C.	7,100	6.00
	2	15.5° C.	6,900	6.00
	4	23° C.	7,100	4.50
	6	26° C.	8,000	3.00

TABLE 2

Effect of blanching on resazurin reduction time in fresh green peas

Sample No.	Blanch period	Aerobic mesophilic bacteria/gram	Replicates	Color eval. of resazurin[1] Hrs. 1	2	3	4	5	6
	(seconds)								
1	0	16,500	1	0	0	2	....	2	24
			2	0	2	2	....	2	24
			3	0	0	2	....	3	24
			4	0	2	2	....	3	24
2	15	1,350	1	0	2	4	....	5	24
			2	0	2	4	....	5	24
			3	0	0	4	....	5	24
			4	0	2	4	....	5	24
3	30	1,100	1	0	5	6	....	7	24
			2	0	4	6	....	7	24
			3	0	4	6	....	7	24
			4	0	4	6	....	7	24
4	60	4,240	1	0	6	7	....	9	24
			2	0	6	7	....	9	24
			3	0	6	7	....	10	24
			4	0	6	7	....	9	24
5	120	950	1	0	8	8	....	11	24
			2	0	8	8	....	11	24
			3	0	8	8	....	11	24
			4	0	8	8	....	11	24

[1] Color assessed using Munsell color standards whereby blue = 0, lavender = 4, mauve = 8, pink = 12 and white = 24.

had been held in frozen storage for 2–2½ months through sterile sintered glass filters. Comparisons made between these filtrates and unfiltered portions showed little difference in reduction times. It is suggested that the sterile filtrate contained sufficient normal reductones produced either by the original blanching, or by prolonged storage or both, to cause a dye reduction rate very similar to that of the unfiltered raw sample. A different picture might have been obtained had some means of O_2 removal been tried. Eagles *(3)* found that 3½ million thermoduric micrococci per ml. of milk were required to reduce resazurin in 3 hours, 170 minutes to reduce the O_2, and 10 minutes for the reduction of resazurin when the O_2 had been removed.

The effect of ascorbic acid on resazurin reduction. It was considered desirable to determine the cause of the dye reduction in the foregoing tests using sterile filtrate. The small number of microorganisms present in the 0.5 g. of dried milk was not the cause since control tubes showed no reduction during a much longer incubation period. Reductones are known to be reducers of dyes, though possibly slow in action *(7, 12)*, and vegetable constituents consume O_2 thereby assisting in the reaction. The ascorbic acid content, which may vary in vegetables with maturity or conditions of growth, was also considered as a possible reducer of resazurin. Comparisons were made of reduction times in 3 samples of peas using standard inocula and inocula to which additional ascorbic acid was added at the rate of 10 mg./100 ml. The test was repeated 24 hours later using the same 1:1 dilutions of the products held since the previous day at 40° F. There was no definite indication that additional ascorbic acid increased the rate of dye reduction (Table 3). The same dilutions of products held 24 hours before testing for resazurin reduction again showed considerably faster reduction but additional ascorbic acid had no apparent effect on the rate. Although not shown in the table, similar tests using boiled inocula extended the dye reduction time by only 10–15% in both initial and 24 hour analyses. The control tubes showed little or no evidence of color change at 7 to 7½ hours incubation, which again suggests that natural reducing agents were active.

TABLE 3

Effect of ascorbic acid on resazurin reduction times in analyses of frozen vegetables

Sample No.	Mesophilic bacteria count/ gram (x 10^3)	Reduction time (in hours) Initial		Held 24 hr. at 40° F.	
		Normal	10 mg. AA/ 100 ml.	Normal	10 mg. AA/ 100 ml.
1	89	5	4.5	4	4
2	195	7	7	5	5
3	50	7	7	5	5
Controls	0	No red'n at 7 hrs.		Very sl. red'n at 7.5 hrs.	

DISCUSSION

Although it has been suggested by Proctor and Greenlie *(8)* that a version of the resazurin reduction test as applied to the examination of milk might be used for estimating numbers of bacteria in frozen vegetables, no published data have appeared to support this claim. On the contrary, results obtained here tend to substantiate statements made by Johns *(5)*, that large numbers of dormant bacteria frequently cause little or no color change for varying periods in milk. The same author also stated that with prolonged refrigeration it may take longer for bacteria to reach their maximum growth rate than would otherwise occur. This is equally true for frozen vegetables in which types of microorganisms vary more widely. These different types of bacteria also vary in their ability to reduce dyes *(2, 4, 5)*, a factor which is responsible, at least in part, for the similar reduction times in samples with widely varying bacteria counts.

The amount of O_2 in the corked tubes under test may also influence the rate of resazurin reduction but this was controlled as much as possible by using a standardized procedure. However, types of bacteria differ in their respiration requirements, and it is expected that the O_2 may be utilized before reduction of resazurin begins. As has already been mentioned, Eagles *(3)* reports that the time required to reduce the dye might be much shorter than that required to consume the O_2. Johns *(5)* also states that O_2 consumption is proportional to the protoplasmic mass,

therefore larger cells generally may take up O_2 more rapidly than smaller ones. This, too, may explain the wide variations in dye reduction times in samples of similar bacteria counts.

The reduction of resazurin in tests with boiled inocula, though generally slower than in the tests with non-boiled inocula, suggests the presence of some heat-stable, vegetable constituents capable of reducing the dye, or the presence of certain natural reducing agents. This would confirm the statement by Johns *(5)* that "other vegetable constituents, as well as bacteria, may consume O_2 and influence reduction time where a few bacteria are present" and also the statement that "reductones occur in cooked, preserved and stored food materials" *(12)*. Resazurin reduction rates, therefore, may vary with the type of blanch and length of storage of the finished product, further reasons for the wide variations found in resazurin reduction times in samples of similar microbial content.

SUMMARY

This study showed that the rate of reduction of resazurin dye was not necessarily proportional to the numbers of aerobic, mesophilic bacteria present in frozen vegetables. Dormancy of these microorganisms influenced the rate of reduction of the dye as shown by the fact that little or no difference in reduction times was found in high and low count samples when analysed immediately after removal from frozen storage. Suspensions of these samples held for 4 to 6 hours at approximately 26° C., however, showed a much faster reduction of the dye in high count samples, indicating that some of the bacteria had become active.

Blanching of fresh peas produced reducing agents in the product. This was quite marked in samples initially low in bacterial numbers as shown by the earlier color change in the blanched as compared with the raw product.

Vegetables which had been held in frozen storage for 2–2½ months contained reducing agents in addition to microorganisms as evidenced by similar rates of dye reduction in sterile filtrate and unfiltered portions of these vegetable suspensions. Further tests indicated that the addition of ascorbic acid caused no noticeable increase in the rate of reduction.

For these reasons, as well as for the established fact that types of microorganisms vary in their ability to reduce the dye, it is concluded that the number of bacteria in frozen vegetables cannot be estimated with any reasonable degree of accuracy by this method.

Acknowledgment

The authors are deeply grateful to Mrs. Jean Ross for technical assistance.

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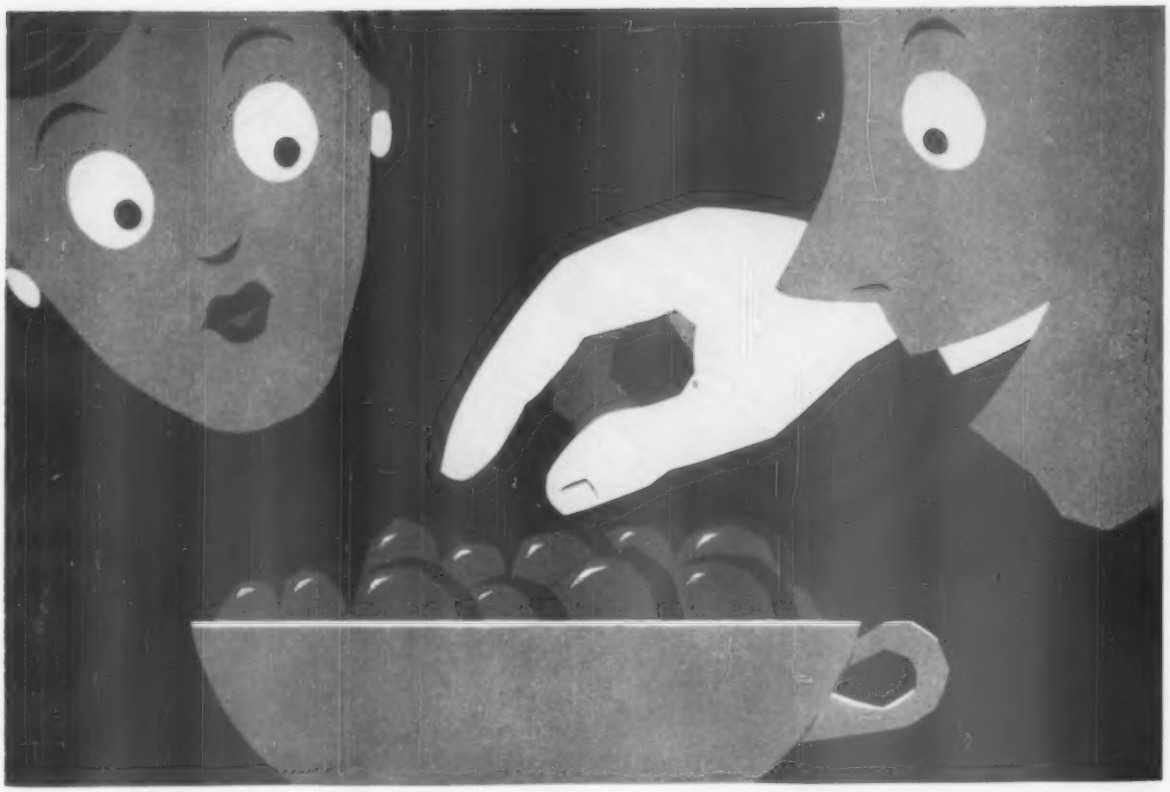

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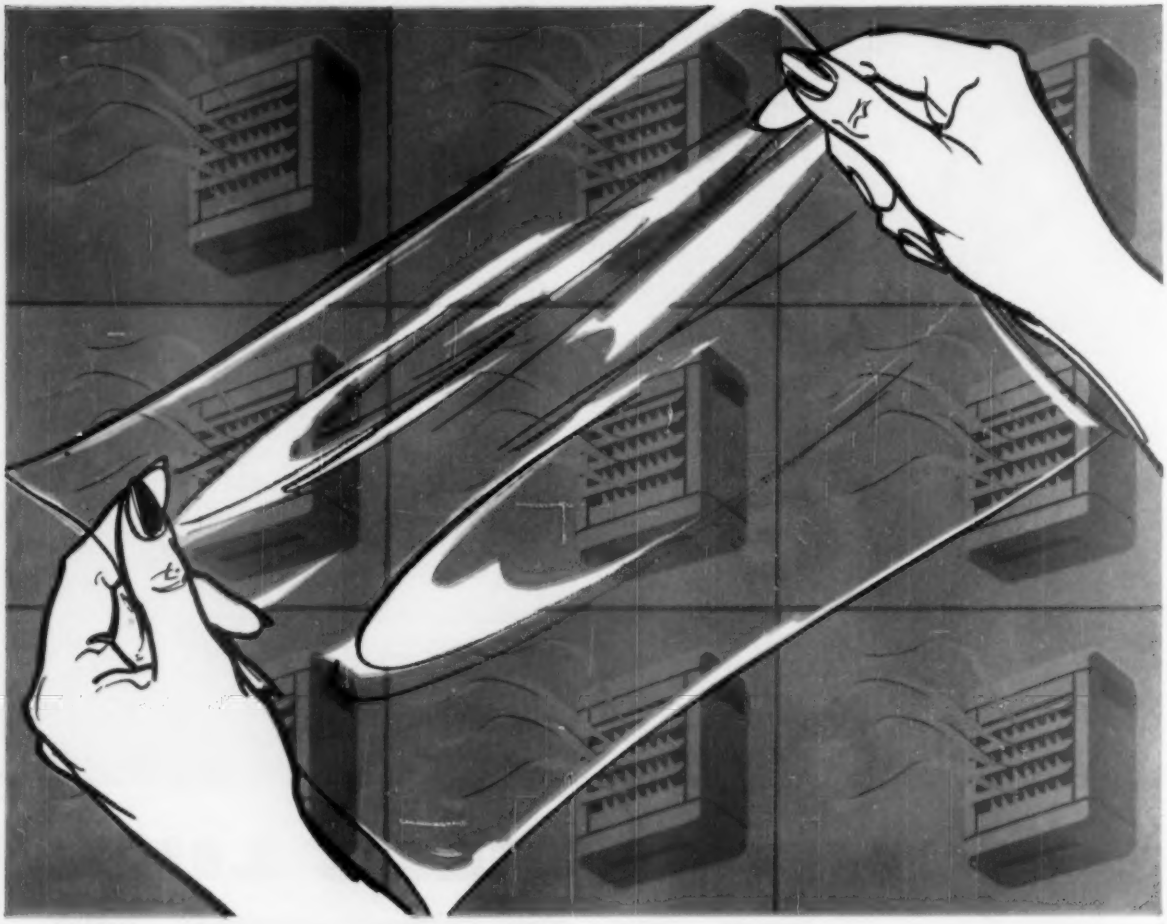

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Time-Temperature Tolerance of Frozen Foods. XIV.

Ascorbic Acid and Its Oxidation Products as a Measure of Temperature History in Frozen Strawberries

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(Manuscript received May 9, 1958)

In a recent publication *(2)*, a close correlation was reported between loss in reduced ascorbic acid (ASA) and quality deterioration in frozen strawberries as judged by color and flavor changes. In the samples used the original ASA content was known and losses were determined periodically at temperatures from 0 to 30° F. It was pointed out, however, that original ASA content varied markedly with growing area, climatic conditions, etc. Therefore the ASA content in any random sample of frozen strawberries will not necessarily indicate the relative degree of time-temperature exposure.

Determination of ASA, dehydroascorbic acid (DHA), and 2,3-diketogulonic acid (DKA) on a limited number of samples indicated that the sum of these compounds remained relatively constant during extended storage at 20° F. *(2)*. If this observation holds for a wide variety of times and temperatures, the sum of ASA, DHA, and DKA would yield the original value, regardless of time-temperature exposure. By subtracting the ASA value from the sum, an estimation of the oxidized ascorbic acid (DHA + DKA) is immediately available. From a knowledge of the average rate of ASA loss for a given temperature, it would then be possible to determine the equivalent time-temperature exposure of any given sample by merely dividing the total amount oxidized by the known rate of oxidation and thereby obtain an estimate of the change in quality of that particular sample.

This paper presents results on ascorbic acid changes during storage under a variety of time-temperature conditions, and shows that the sum of ASA, DHA, and DKA remains relatively constant under conditions which might be encountered from the time of harvest to actual consumption.

MATERIALS AND METHODS

Strawberries used were the Shasta, Lassen, Marshall, and Northwest varieties. To determine original values of ASA, DHA, and DKA, the berries were frozen in less than one minute after picking by immersion in a dry-ice, alcohol bath. The frozen berries were then stored at −20° F. until analyzed. In addition to several small samples of berries (approximately 1 lb. each) handled in this manner, large lots (50 crates) of fresh "freezer" berries were obtained for processing and storage at various temperatures. Some of these berries were held whole at 35° F. and at room temperature (about 70° F.). The remainder were washed, sorted, sliced (¾-inch thick), mixed with sugar in a 4 + 1 ratio, packed in unwaxed pint paper tubs, and frozen at −20° F., except some samples which were held at room temperature without freezing. The latter samples were analyzed for ASA, DHA, and DKA at regular intervals. The frozen samples were then stored at 0, 10, 20, and 30° F. and analyzed for ASA, DHA, and DKA periodically.

Analytical. Fresh or frozen berries (300–500 g.) were blended to a uniform slurry with an equal weight of 10% metaphosphoric acid in a blender. Five to 6 g. of slurry were weighed to the nearest 0.01 g. and diluted to 200 ml. with a 5% solution of metaphosphoric acid. This solution was filtered through fluted filter paper and aliquots of the filtrate were used for analysis of ASA, DHA, and DKA. These 3 compounds were determined by the method of Roe *et al. (5)* except for the omission of stannous chloride which was found unnecessary in strawberry extracts. ASA was also determined by the dye method described by Loeffler and Ponting *(4)*.

RESULTS

Effect of temperature on total ascorbic acid content (ASA + DHA + DKA). Total ascorbic acid content of fresh whole berries remained constant for about 2 weeks at 35° F. and 2 to 3 days at 70° F. These time-temperature conditions represented about the maximum that the fruit could be held without undue loss from mold and rot. These observations were based on 2 lots of berries which were analyzed at 1-day intervals for 4 days and thereafter the berries held at 35° were analyzed at 2- or 3-day intervals up to a total time of 2 weeks. In agreement with results for whole fresh berries, and contrary to results reported on frozen vegetables *(1)*, total ascorbic acid content of frozen sugared sliced berries remained relatively constant at temperatures of 0°, 10°, 20°, and 30° F. for 12 months, 9 months, 4 months, and 1 month, respectively. These observations were based on 3 varieties which were analyzed daily for the 30° storage and at longer intervals for the lower temperatures (12-day intervals for 0° F.).

At 0° F. there was little change in ASA, DHA, and DKA as well as in the sum of these three compounds, but at 10°, 20°, and 30° F. ASA was almost completely converted to DHA and DKA after extended storage. An example is shown in Figure 1. At unfavorable temperatures ASA is rapidly oxidized to DHA, which eventually hydrolyzes to DKA. Under the conditions of these experiments DKA appears to be the end product of the degradation; otherwise the sum of the 3 compounds would gradually decrease instead of remaining constant. The fact that this sum remains constant under a wide variety of time-tempera-

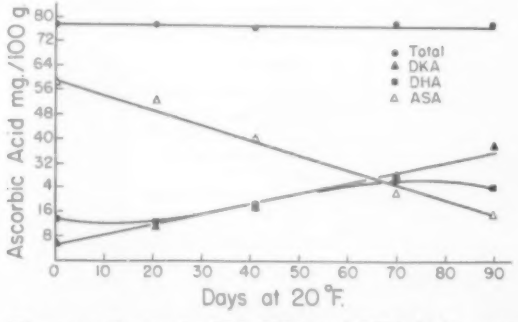

Figure 1. Changes in ASA, DHA, and DKA during storage at 20° F.

[a] Western Utilization Research and Development Division, Agricultural Research Service, U. S. Department of Agriculture.

ture conditions is significant because it allows for estimation of the original ascorbic acid content in any given sample of berries.

Variation of ASA, DHA, and DKA in freshly harvested fruit. As shown in Table 1, ascorbic acid in freshly harvested fruit is largely in the reduced form. It is interesting that small amounts of DHA and DKA are apparently present in the berry while still attached to the plant. The sum of these 2 compounds averages 9 to 10% of the total immediately after harvest and therefore should be subtracted from the total in order to estimate the true ASA content in freshly harvested fruit.

It is recognized that DHA is antiscorbutically active and from a nutritional standpoint should not be placed in the same category as DKA, which has no antiscorbutic potency. The purpose here, however, is the use of these various products as a measure of temperature history rather than nutritional value. Furthermore, oxidation or loss of ASA is a more sensitive measure of temperature damage than the accumulation of DKA alone. Another advantage in expressing temperature abuse in terms of ASA loss is that extensive data have been collected on rates of ASA loss at various temperatures *(2)*. In addition, the procedure for determining oxidized ascorbic acid (DHA + DKA) is much simpler and less tedious than measuring each compound individually.

Analysis of 15 strawberry samples ranging from 23 to 68 mg./100 g. of ASA by both the Roe and the dye methods gave a mean value of 47 mg./100 g. for each method. The experimental error is 1.7, indicating good precision for both methods. Thus it is possible to determine only total ascorbic acid (ASA + DHA + DKA) by the Roe method and ASA by the simpler and much more rapid dye method. The loss in ASA may then be determined by subtracting the ASA value found by the dye method from 0.9 of the total ascorbic acid as determined by the Roe method. It is recognized that loss of ASA obtained in this manner is not necessarily accurate for all samples. However, Table 1 shows that 89 to 91% of the total ascorbic acid in 7 out of 10 fresh samples tested was in the ASA form, and therefore 0.9 of the total appears to be a reasonable approximation of the ASA content in freshly harvested fruit.

Ascorbic acid changes after harvest. As shown in Figure 2, rather rapid losses in ASA with corresponding increases in (DHA + DKA) occurred in whole fresh berries stored at 70° F. At 35° F. these changes occurred at a much slower rate (approximately ⅛ of the rate at 70° F.). It is clear that substantial losses in ASA can occur within 24 hours if the fruit is allowed to stand at room temperature. In this case (DHA + DKA) increased from about 10 to 25% of the total (ASA + DHA + DKA) and the increase is accompanied by an easily detectable flavor change in the fruit. Obviously, oxidized ascorbic acid (DHA + DKA) in frozen strawberries may be due to delays in handling the fresh fruit as well as improper handling of the frozen product during distribution.

Figure 3 shows the ascorbic acid changes in sliced sugared berries during holding at room temperature. It is interesting to note the effect that slicing alone has on increase in (DHA + DKA). The sum of these 2 products amounted to 12% of (ASA + DHA + DKA) in whole berries but immediately after slicing and sugaring the combined (DHA + DKA) amounted to 22% of the total. Slicing exposes much more surface area to

TABLE 1

Comparison of ASA, DHA, and DKA in freshly harvested strawberries

Sample	As ascorbic acid, mg./100 g.				% of total as ASA
	ASA	DHA	DKA	Total	
1	82	5	3	90	91
2	69	4	3	76	91
3	65	5	2	72	90
4	62	4	1	67	92
5	59	5	2	66	89
6	56	3	4	64	88
7	53	6	3	62	85
8	53	5	1	59	90
9	52	2	4	58	90
10	49	4	2	55	89

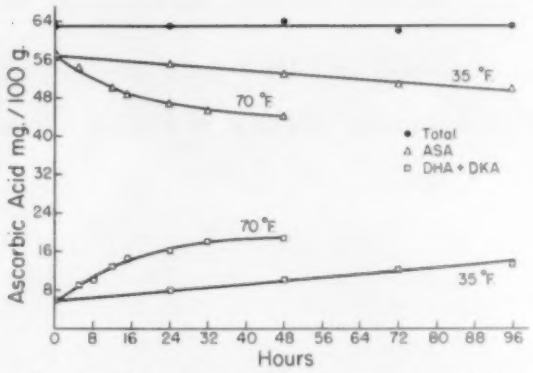

Figure 2. Effect of time and temperature on ascorbic acid changes in fresh whole stemmed strawberries.

oxygen, and hence it would be expected that substantial amounts of ASA could be oxidized during this operation. In addition, ASA is rapidly oxidized to (DHA + DKA) during holding of the sugared slices at room temperature. It is recognized that after the fruit is sliced, sugared, and packaged, delays at room temperature are held to a minimum. However, it is also true that temperatures may remain high for fairly long periods of time, especially during "pallet freezing." Therefore, it is clear that considerable amounts of ASA are oxidized or lost during processing and freezing as well as during pre-processing delays. If we assume the case where berries are processed 24 hours after harvest and remain in the neighborhood of 70° F. 4 hours after slicing, as much as 45 to 50% of the total ascorbic acid could be in the oxidized forms (DHA + DKA).

A certain amount of delay between harvest and processing and between processing and freezing to 0° F. is unavoidable. Under experimental conditions, a 6-hour delay prior to processing plus 4 hours to bring the sliced packaged product down to 0° F. resulted in an accumulation of (DHA + DKA) which amounted to approximately 25% of the total. In this connection it is interesting that the (DHA + DKA) content of 10 commercial samples of sliced strawberries packed under normal conditions averaged 26.5 ± 1.0% of the total ascorbic acid, which ranged from 47 to 86 mg./100 g.

Ascorbic acid changes after freezing. A typical example of the accumulation of (DHA + DKA) in frozen strawberries packed in nonhermetic containers and held at 0 to 30° F. is shown in Figure 4. As mentioned earlier, it is clear that ASA is rapidly converted to DHA and DKA at temperatures of 10 to 30° F. with very little oxidation occurring at 0° F. The rate of accumulation increased approximately 5-fold for every 10° F. rise in temperature (0 to 30° F. range). These results are very similar to those reported for various commercial samples (2).

Since the rates remain constant until most of the ASA is oxidized, it is convenient to express temperature history as the

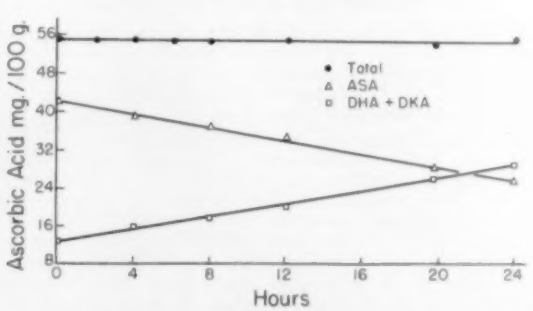

Figure 3. Effect of delay at room temperature (70° F.) on ascorbic acid changes in fresh sliced sugared strawberries (4 + 1).

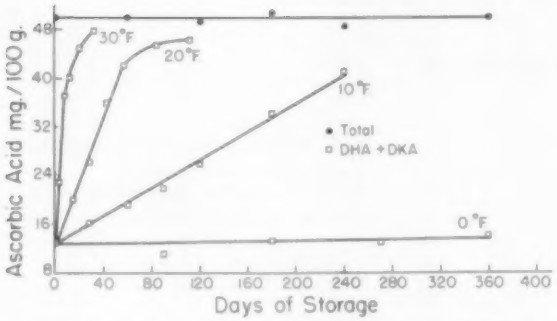

Figure 4. Effect of time and temperature on accumulation of (DHA + DKA) in frozen sliced strawberries (4 + 1).

equivalent number of days of storage at some "reference" temperature for which the rate of ASA loss is known. This may be done by dividing the observed ASA loss by the rate at the selected temperature and this will give the approximate number of days at that temperature.

DISCUSSION

Total ascorbic acid remains constant under time-temperature conditions likely to occur during handling and distribution of frozen strawberries. An objective procedure for estimation of quality loss that results from improper handling is thus provided. It is important to emphasize, however, that these quality changes, as measured by ASA loss, can and do occur prior to freezing as well as during improper storage after freezing. Measurement of total and reduced ascorbic acid provides an estimation of the total oxidation and corresponding quality loss which has occurred from the time of harvest but does not distinguish as to when or where the damage occurred. Obviously, if the measurements are made immediately after processing or freezing, the oxidation which is indicated will have occurred prior to and during these operations alone. On the other hand, the ASA loss found in random samples of frozen berries picked up in marketing channels represents the sum of all the oxidation which has occurred in the life of that particular sample.

From these studies it appears that strawberries after harvest, processing, and freezing may have oxidized ascorbic acid (DHA + DKA) which is about 30% of the total. Commercial samples and experimentally prepared packs with oxidized values of 25 to 28% of the total were considered high-quality frozen strawberries. Since about 10% of the total is measured as (DHA + DKA) in the freshly harvested berries, another 10 to 12% is oxidized during slicing alone, and approximately another 5% is oxidized during unavoidable delays from harvest to freezing, total oxidized values of at least 25% appear to be unavoidable and in no way represent poor handling, processing or freezing practices. Therefore a more accurate estimation of poor handling and storage conditions will be obtained if only 75% of the total is regarded as the original ASA value. The difference between 75% of total ascorbic acid and the actual ASA value in any given sample will be roughly proportional to quality loss in that sample. As mentioned earlier, this observed ASA loss may be expressed in terms of equivalent number of days of storage at some reference temperature such as 20° F. by simply dividing the observed loss by rate of loss per day at the reference temperature.

That changes may have occurred at variable temperatures higher and lower than 20° F. is unimportant since it has been shown that a given loss in ASA is equivalent to approximately the same degree of flavor and color change over a wide range of temperatures *(2)*. Furthermore, it has been shown that changes occurring at fluctuating temperatures can be explained on the basis of steady effective temperatures *(3, 6)*. Therefore loss of ASA can be looked upon as an automatic integrator of all the varied unfavorable temperature experiences that the product has encountered. The only requirement for this estimation is determination of total and reduced ascorbic acid.

SUMMARY

Data are presented to show that total ascorbic acid (ASA + DHA + DKA) in frozen strawberries remains constant under a wide variety of time-temperature conditions. This permits estimation of the original ascorbic acid content of any given sample of berries regardless of temperature history. Loss in ASA can and does occur prior to processing, during slicing and sugaring, and prior to freezing as well as during frozen storage. Therefore, total ASA loss represents total damage which occurred both prior to freezing and during subsequent frozen storage. A simple procedure for estimating the equivalent time-temperature exposure of any given sample of frozen strawberries is given.

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Radiation Preservation of Milk and Milk Products

VII. Storage Studies on Milk Subjected to Cobalt-60 Radiation Distillation[a,b,c]

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PROBLEMS CONNECTED with changes in flavor and color of irradiated milk have been described previously *(7)*. By distillation during irradiation under vacuum the formation of off-flavors was controlled, and acceptable flavor levels were achieved in milk irradiated with two million rep. Such processes were carried out with gamma rays from a Cobalt-60 source as well as with high energy electrons in an apparatus described in the previous paper. Further experimentation indicated however, that the control of off-flavor development was only one part of the problem to be solved if ionizing radiations were to be used to sterilize milk. It became evident that radiation-sterilized milk possessed poor storage stability.

The present study was undertaken to delineate the problems involved and to suggest possible avenues of further research. Changes made in the apparatus, which is described herein, made it possible to prepare sterile samples of irradiated milk. It was found that changes occurred which were especially pronounced at and above room temperature storage. After a few days' storage at 30° C., the irradiated milk started to become brown and the intensity of the brown color progressed with time. Furthermore, an increase in viscosity was observed and finally, gel formation occurred. Upon continued storage, the gel separated into curd and whey. The stored milk which had become brown possessed a caramelized flavor which was slightly astringent.

These storage changes were found to be somewhat similar to phenomena reported to occur in evaporated milk on storage. The present study was undertaken to evaluate the importance of different variables in the process of irradiation and in storage. The more important of these variables could be expected to lie in (1) the irradiation process: temperature, concentration of milk, dose rate, dissolved oxygen, kind of radiation, and in (2) storage: temperature, concentration of milk and dissolved oxygen. Other variables in the irradiation process, such as distillation rate and total distilled water have previously been shown to affect the quality of the freshly processed milk with respect to flavor and other characteristics. It is thus evident that these variables plus combinations of processing and storage parameters constitute a very large number of possibilities.

Samples of milk, irradiated with either gamma rays from Cobalt-60 or with high voltage electrons, distilled and not distilled, were used in these experiments. This selection of samples has enabled the study of the effects of dose rate and type of irradiation, as well as the effect of distillation on the storage characteristics of the milk.[d]

EXPERIMENTAL

Sampling of sterile Cobalt-60 irradiated-distilled milk.

The distillation apparatus used in the Cobalt-60 source has been described previously *(7)*. Certain modifications of this apparatus were necessary in order to achieve actual sterilization of the samples. Because of the initial foaming at the beginning of distillation, the original apparatus had a large flash-chamber on top of the boiler. To avoid the necessity of having a flash-chamber, which would cause contamination of the sterile milk in the boiler, the milk was precondensed to double concentration. The upper extension of the boiler (Figure 1) was wrapped in a heating tape to avoid reflux which would have deleterious effects on the flavor. At the bottom of the boiler, a short tube was installed, closed with a serum cap to allow the removal of samples under sterile conditions. A Cryovac barrier between the rubber serum cap and the milk prevented any diffusion of irradiation off-odors from the rubber into the milk. Sterile make-up water from pre-sterilized equipment was introduced into the boiler during the process. Close control of the milk volume was achieved by condensing the vapors by means of circulating brine at 36° F. Graduated traps, immersed in a brine

[a] This paper reports research undertaken in cooperation with the Quartermaster Food and Container Institute for the Armed Forces, and has been assigned Number 920 in the series of papers approved for publication.

[b] Contribution Number 357 from the Department of Food Technology, Massachusetts Institute of Technology, Cambridge.

[c] Presented at the Eighteenth Annual Meeting of the Institute of Food Technologists, Chicago, Illinois, May 26, 1958.

[d] Dose used in these studies was 1.86×10^6 rad unless specifically noted otherwise.

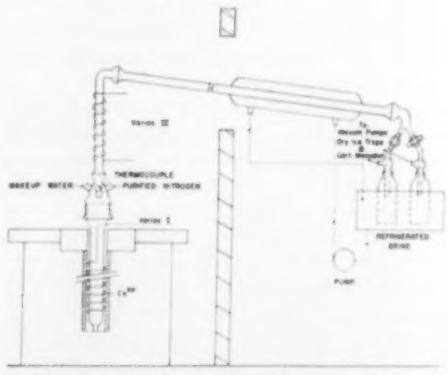

Figure 1. Radiation distillation apparatus.

bath, allowed direct observation of the volume of the condensate. When the milk had received the required dose (1.86×10^6 rad) samples were aseptically withdrawn and introduced into sterile ampoules, which after evacuation were sealed.

Storage samples of high voltage electron irradiated and distilled milk

A device for the processing of milk under conditions similar to those just described for the Cobalt-60 source, but using high voltage electrons, has been described in the previous paper *(5)*. Samples of this milk were not sterile, due to characteristics of the apparatus. Therefore, the milk samples intended for storage studies had to be stabilized by some means in order to avoid bacterial spoilage during a period of time sufficient to obtain the desired results. Storage experiments of double concentrated milk containing combinations of antibiotics at various levels of concentration were conducted in order to find a combination of antibiotics that would preserve the milk for the length of time necessary to obtain the desired data on the browning and gelling properties. Chlortetracycline at a concentration of 500 p.p.m. appeared to preserve the milk well. The color of this antibiotic interferes, however, with the determination of the intensity of the brown discoloration of the milk. Similarly, a combination of Bacitracin and Polymixin, that also preserves the milk, might well, due to their polypeptide nature, be suspected of interfering with the gelation. For these reasons, the milk in the subsequent storage studies was preserved with a combination of penicillin, streptomycin and chlortetracycline, giving a concentration in the milk of 500, 500, and 100 p.p.m. of these antibiotics, respectively. Unsterile irradiated milk treated in this way has been stored for several months at 30° C. without giving aerobic or anaerobic growth or change of pH. The same amount of antibiotics was added to unirradiated controls before analysis for brown color was made. This method of preservation would, by itself, be of little value as a means of studying storage stability. However, the results agree with those of samples sterilized by other means and were therefore presented with these. It became evident by comparison that these antibiotics interfered little, if at all, with the development of brown color and of gel formation.

Other milk samples for storage were obtained by sterilizing the milk in ampoules. Such samples were irradiated with gamma rays from a Cobalt-60 source or with high voltage electrons of 2 M.e.v. Ten milliliter capacity and 5 ml. capacity ampoules were half-filled with milk and sealed under vacuum.

ANALYTICAL

Browning. The development of the brown color was followed analytically by a modification of Choi's method as described by Werthheim *et al.(6)*. The absorbance at 360 mμ of milk serum obtained by tryptic digestion and precipitation of proteins with tricholoroacetic acid is measured by this method. Two series of data were collected: the "brown color" which is the reading obtained without any heat treatment, and the "browning sensitivity" of milk that has been heated for 20 minutes at 100° C. Both of these values were sometimes recorded relative to a reference color as the percentage retention of a reference color. The brown color of unconcentrated milk irradiated with a dose of 1.86×10^6 rad and heated for 20 minutes at 100° C. was used as a reference value.*

Gelling time in storage. Milk concentrated to 1:3 or 1:2 and irradiated with 1.86×10^6 rad gels after a certain time in storage at or above room temperature. The formation of a gel is preceded by an increase in viscosity, but, as this is a gradual change, it is not well suited for objective measurements. During the period of thickening, the milk samples should not be disturbed or agitated as this will delay or inhibit the formation of a gel. For this reason, several equally treated samples were stored simultaneously. When the samples were inverted for inspection of gel formation at different times, one sample at least had to remain undisturbed until a solid gel had been formed.

* Reference value was obtained by irradiation, with gamma rays, of milk in vials (out of apparatus). Value was 1.60.

Total solids content of milk samples was determined by drying on a steam bath, followed by three hours at 100° C. in a drying oven *(2)*.

Organoleptic evaluation of irradiated and distilled milk samples.

A taste panel consisting of six trained judges was used. Samples were submitted in a triangle arrangement. A special score system was introduced by acquainting the judges with off-flavor intensity of conventionally (without distillation) irradiated milk that had been subjected to a dose of 1×10^5 rep, to which a score of 10 was assigned. A value of zero indicated no off-flavor and a score of three indicated the limit of acceptability.

RESULTS AND DISCUSSION

Preliminary work *(4)* indicated that some of the enzyme systems of milk might be more sensitive to inactivation when irradiation was carried out at somewhat elevated temperatures. Peroxidase and lipase were inactivated at temperatures above 40° C. when irradiated with 1.86×10^6 rad, although at room temperature this dose was insufficient to destroy these enzymes. For this reason and also to control the amount of liquid condensate more accurately, the condensing system was changed from dry ice traps to brine temperature of 2° C., and the installation of a manostat allowed control of vacuum and temperature at higher levels.

Figure 2 shows that a correlation of taste scores and temperature during irradiation seems to exist and that those temperature levels which seemed desirable for the inactivation of enzymes gave noticeable flavor changes under otherwise equal processing conditions and evaporation rates of 150–200 ml./h. Table 1 gives the compiled results of a series of runs. The application of temperatures above 50° C. for the first 90 minutes of the eight-hour irradiation period and tem-

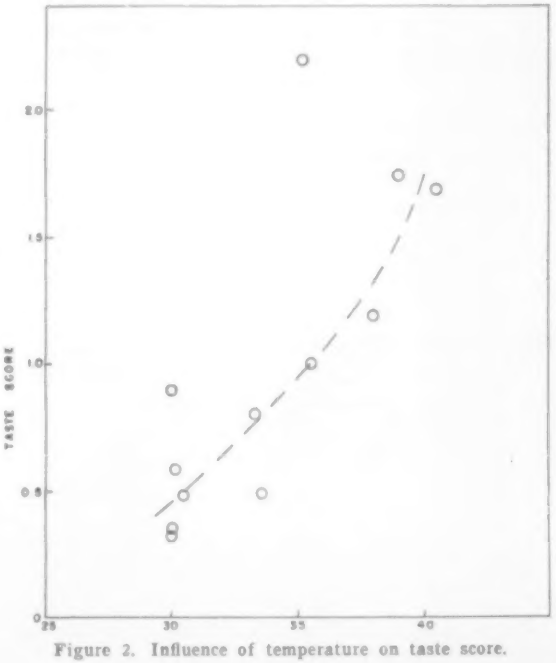

Figure 2. Influence of temperature on taste score.

TABLE 1

Run No.	Irrad. temp. ° C.	Evap. rate ml./h.	Taste score
1	30.6	207	0.50
2	33.4	206	0.80
3	35.3	187	2.20
4	35.5	180	1.00
5	38.0	206	1.20
6	39.0	197	1.75
7	40.5	170	1.70
8	47.5 30.0 33.6 [1]	193	0.50
9	52.0 29.8 [1]	180	0.90
10	54.0 29.8 [1]	.....	0.59
11	55.0 29.8 [1]	157	0.34

[1] First 60–90 minutes, high temperature.

peratures around 30° C. for the remainder of this period, resulted in milk of good flavor scores (0.0 to 1.0). Further studies should reveal whether enzyme inactivation can be achieved by this method. Retention of browning sensitivity of reference value was 25–35% and did not materially change from results which were previously reported when irradiation and distillation were carried out at 5–10 mm. Hg throughout the total irradiation period.

It has been previously reported *(7)* that relatively stable peroxides are formed in the saturated glycerides of the milkfat during irradiation. The effect noted above is believed to be due to the formation of such peroxides from residual free oxygen present in the milk during the early part of the irradiation, and the subsequent decomposition of the peroxides at the temperatures used during this phase of the process. Off-flavor compounds formed will then, during the remaining period, volatilize and be removed due to the higher vacuum used. As judged from the odor of the vapor traps, putrid-like flavor compounds are also being removed efficiently during this latter period.

Gelation. Results compiled from a series of storage experiments at 30° C. are shown in Figure 3. Included here is milk from which off-flavor compounds have been removed as well as milk which contains off-flavor compounds (undistilled), and milk irradiated with gamma rays and with electrons at two different dose rates. Gelling time is plotted against the total solids content (T.S.) of the milk. Data obtained from these widely different experiments form points that lie close to a curve (as indicated). It is therefore inferred that the dose rate, type of irradiation, and distillation are of little or no significance in determining the gelling time of milk irradiated with a dose of 1.86×10^6 rad. The same consideration might be given to the effect of temperature during the irradiation, inasmuch as in these experiments it varied between about 10° C. and 50° C. Between these limits the temperature therefore appears to have no effect on the gelling time. The important variables appear to be the total solids content of the milk and the storage temperature.

The effect of the storage temperature on the gelling time of milk irradiated with high voltage electrons is illustrated in Figure 4. Each curve represents a given storage temperature. It is seen that the effect of decreasing the storage temperature is a decreased slope of the gelling time/T.S. curve. No new factor such as an increased enzymatic activity is apparent from the general trend of the curves. Such effects would have shown up as irregularities in the temperature/gelling time curves at the optimal temperatures of such active enzyme systems. The effect of the storage temperature is perhaps better illustrated in Figure 5 where gelling time is plotted against storage temperature at different levels of total solids content. A double concentrated milk gels at 30° C. in about 14 days, whereas a triple concentrated milk at the same temperature gels after only 3 days. At 20° C. these gelling times are approximately doubled, whereas a storage temperature of 5° C. evidently will preserve the milk for several months.

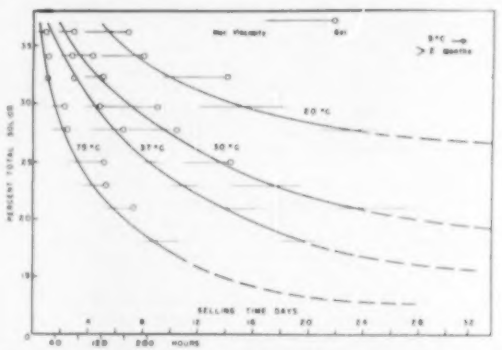

Figure 4. Gelling time as influenced by total solids at various storage temperatures.

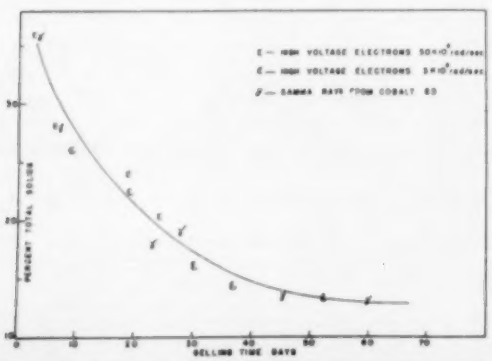

Figure 3. Gelling time at 30° C. of milk of different total solids content irradiated at different sources.

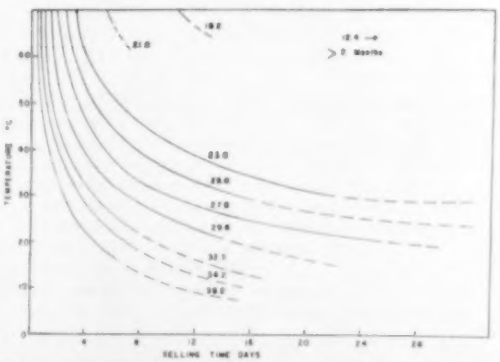

Figure 5. Gelling time as influenced by storage temperature. Milk of different total solids content.

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Effect of additives on gelation. From the evidence presented in these studies it appears that certain changes in processing conditions such as temperature, rate of irradiation and evaporation, did not measurably influence the stability of the irradiated milk on storage. Therefore, additional means will have to be devised to achieve longer storage life at elevated temperatures. In order to decrease residual reactivity after irradiation, the effects of certain additives are being studied. Different concentrations of colloid stabilizers such as gelatin, agar-agar and sodium alginate have been tested. No conclusive evidence has yet been obtained, but it is indicated that these compounds will have little effect on the gelling time. The effect of altering the calcium balance of the casein by the addition of compounds such as sodium citrate and sodium oxalate, enhances, rather than slows down, the gelation. Calcium chloride added in small amounts delays the formation of a gel to a limited extent. Larger amounts have the opposite effect. Sulfhydryl compounds such as cysteine, thioglycollic acid, and dithioglycerol give a marked effect in extending the gelling time. These effects will be the subject of a later study.

Browning. When milk that has been irradiated and distilled and protected by the addition of antibiotics is stored, browning develops as is illustrated in Figure 6. These are curves drawn from the observations presented in Table 2. After a few days' storage at 30° C., the brown color and the browning sensitivity both reach the same level. This same level is also approximated by the browning sensitivity of milk stored at 5° C., but the brown color does not change significantly during the period of the experiment. Figure 7 gives similar results obtained from an experiment in which milk was irradiated in sealed ampoules with high voltage electrons. Here the development of browning is followed through a period of 3 months in milks of different concentration. The curves exhibit the same general trend as in the former experiment, and again it is observed that the brown color at 5° C. does not increase from the initial value.

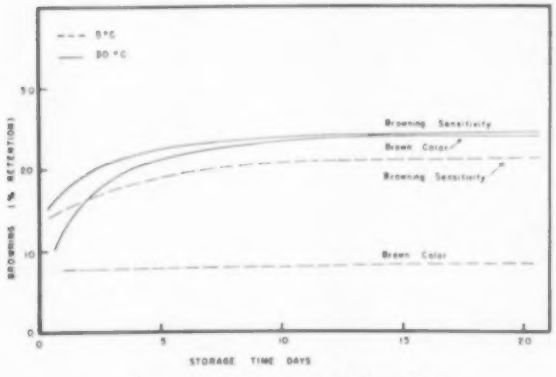

Figure 6. Development of browning.

TABLE 2A
(to Figure 6)

Days in storage	Brown color % ret.		Brown sens. % ret.	
	5° C.	30° C.	5° C.	30° C.
0	(7)	(7)	14.0	14.0
2	7	21.0	13.0	18.5
5	11	20.0	21.5	24.5
12	.....	.....	24.0	26.0
17	9.5	21.0	23.5	24.5
20	7.0	26.5	19.0	27.0

The effect of concentration. The values for browning reported in the work in this paper were all obtained after concentrated milk had been diluted to milk of approximately 12.2% total solids content. Figure 8 illustrates the effect of the concentration. Between the approximate limits of 12% and 28% there is a straight line relationship between the concentration of milk solids and browning sensitivity. If the dilution factors and the brown discoloration of the untreated control are taken into consideration, a straight line parallel with the abscissa is obtained indicating a zero reaction over this region. Above 28% total solids content, additional effects are apparent, increasing the yield of browning precursors.

The effect of dose rate. Three sources of widely different radiation intensity have been used in this study. The Cobalt-60 source of this department emitted, during the period of this study, approximately 60 rad per second, while the electron acceler-

TABLE 2B
(to Figure 7)

Conc. T.S. %	° C.		Days in storage/absorbance 360 mμ						
			4	7	10	15	30	60	90
10.4	5	BC	0.90	0.90	0.92	0.91	0.91	0.95	.....
		BS	1.76	1.78	1.70	1.66	1.60	1.58	1.60
	30	BC	1.18	1.30	1.40	1.40	1.65	1.65	1.70
		BS	1.76	1.50	1.70	1.72	1.70	1.58	1.65
20.6	5	BC	0.61	0.65	0.58	0.66	0.62	0.60	0.68
		BS	1.10	0.90	0.90	0.970	0.89	0.90	0.95
	30	BC	0.89	0.95	0.95	0.98	1.10	1.10	1.15
		BS	1.10	1.01	1.15	1.10	1.10	1.08	1.10
28.2	5	BC	0.53	0.60	0.52	0.52	0.50	0.50	0.58
		BS	0.76	0.74	0.64	0.78	0.65	0.62	0.67
	30	BC	0.75	0.64	0.71	.....	0.81	0.82	0.90
		BS	0.80	0.74	0.75	.....	0.80	0.68	0.81

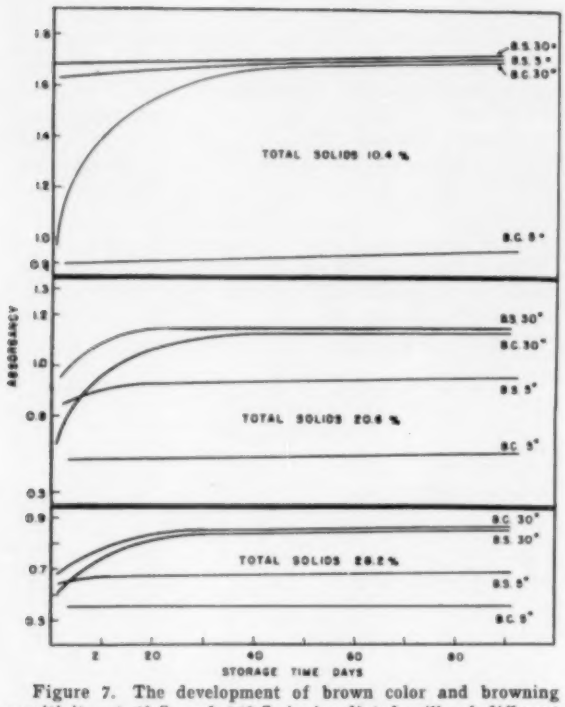

Figure 7. The development of brown color and browning sensitivity at 5° C. and 30° C. in irradiated milk of different total solids content.

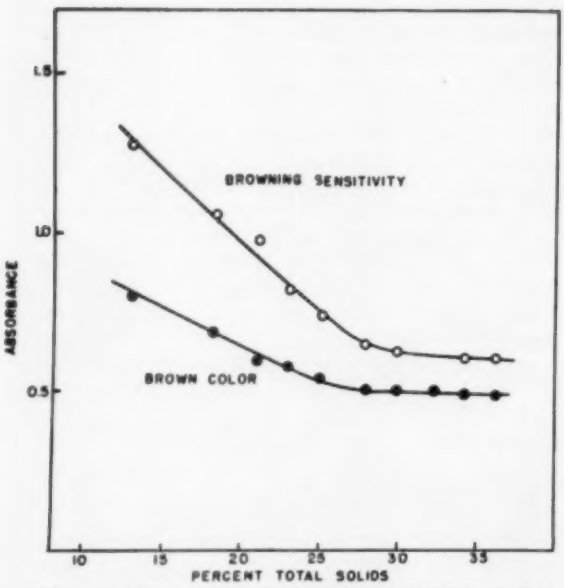

Figure 8. Brown color and browning sensitivity of H.V. electron irradiated milk of different total solids content.

ator gives approximately 3×10^6 rad per second when using the maximum beam current. Another electron accelerator also available for the experimentation, gave an intensity of 50×10^6 rad per second. When results obtained from high voltage electrons were compared with those from gamma rays, a difference in browning was evident. This difference may be due either to the difference in dose rate or to the kind of irradiation. That this difference is probably due to the radiation intensity is suggested from Table 3.

TABLE 3

Source of radiation	Dose rate grams rads/second	Browning sens. % ret. (25% T.S. milk)
High voltage electrons 2 M.e.v. Van de Graaf	50×10^6	12
High voltage electrons 1 M.e.v. elec.accel. .95 mA	3×10^6	15
High voltage electrons 1 M.e.v. G. E. elec. accel. .7 mA	2.0×10^6	21
Electron accelerator 1 M.e.v. .48 mA 2L	1.5×10^6	24
Cobalt-60	6×10^1	30

Effects of oxygen and distillation. It is well known from earlier studies that free oxygen has a profound effect on the irradiation-induced oxidation of the milkfat *(7)*. It has also been found that amino acids and peptides are affected by the presence of free oxygen during irradiation *(3)*. No striking effect has been observed in this study on the amount of browing-precursors formed, although it is considered that the free oxygen may tend to increase the browning sensitivity slightly. Oxygen-free milk, irradiated under a helium blanket, possessed a browning sensitivity only slightly smaller than milk saturated with oxygen during the irradiation. Similarly, distillation probably somewhat reduces the browning sensitivity. Patton and co-workers *(1)* found that acetaldehyde was formed during the irradiation of skim milk. Small amounts of volatile browning precursors may be formed, which may be removed to some extent during the distillation procedure. This would have the effect of reducing the browning. When non-distilled milk was compared with distilled milk, a reduction of only 10% in the absorbance was found, indicating that this effect is only of minor importance.

Attempts to modify the tendency towards browning. It has been reported that sodium ascorbate will reduce the tendency towards browning *(7)* but the effect was only moderate and caused no drastic change in this respect. Sodium sulfite or bisulfite, when added in small amount, is quite efficient in reducing browning (Figure 9). The effect is progressive and it may take a few days in storage before the reaction is complete. Amounts as small as 10 p.p.m. appear to be sufficient to cause a reduction of browning. Milk treated with SO_2 gives absorbance values at 360 mμ which are higher than that which corresponds to the amount of brown discoloration of the serum. In the case of 10 p.p.m. SO_2, little difference in the browning from that of the unirradiated control was observed by visual inspection. The flavor is, at this level of bisulfite addition, not affected. Studies are in progress to establish the exact values of the sulfite flavor tolerance levels.

CONCLUSIONS

The off-flavors formed when milk was treated with ionizing radiations could largely be avoided when

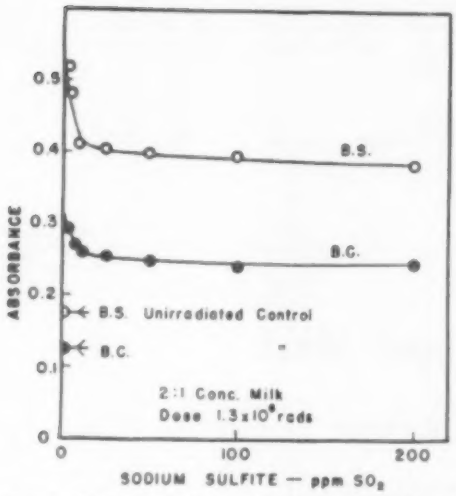

Figure 9. Effect of sodium sulfite on the browning of irradiated milk.

the irradiation process was combined with distillation under vacuum. The flavor of the irradiated milk was found to be dependent on the temperature during the irradiation. The best flavor scores were obtained when the irradiation process was divided into two phases, the first of which involved distillation at a relatively high temperature (approximately 50° C.) for a period of one to one and one-half hours, while the remainder of the distillation time, the milk was distilled at a lower temperature (approximately 30° C. for six to seven hours). This effect is believed to be due to the formation of unstable peroxides being formed from residual free oxygen during the first phase of the process and their decomposition into volatile flavor compounds at the high temperatures. The low temperature with a corresponding high vacuum will, in the second phase of the operation, efficiently strip the milk of these volatile off-flavor compounds. During this phase also, putrid-like flavor material, presumably derived from the milk proteins, is removed.

Storage studies of milk processed in this manner, and in general, milk that has been irradiated with a dose of 1.86×10^6 rad (to achieve sterility), revealed instability. Both browning and gelation have been shown to limit the storage life of this product. An evaluation of the factors that affect these phenomena in a quantitative way, indicates that the gelling time of irradiated milk is independent of the processing conditions that have been tested (temperatures of irradiation between 30° C. and 50° C., type of irradiation—whether gamma rays or high voltage electrons, dose rate, presence or absence of air, whether volatiles were removed by distillation or not). The only factors which appear to be of importance are the total solids content of the milk and the temperature of storage. Triple concentrated milk of total solids content of 36% gels after 2 days' storage at 37° C. and in about 6 days at 20° C. However, at 5° C. it may be stored for months without gelling. Similarly, double concentrated milk of 25% total solids content gells after eight days and 14 days at 37° C. and 30° C., respectively. At temperatures of 20° C. and lower it is stable for months. High viscosity, and therefore, high solids content, is however, required in order to avoid fat separation.

The browning sensitivity of the irradiated milk has been found to be dependent upon the total solid content of the milk while being irradiated and of the intensity of irradiation treatment or dose rate, but independent or nearly so, of the temperature during irradiation and storage within the limits that have been tested, namely 5° C. to 50° C. and 5° C. to 37° C., respectively.

Changes in processing conditions that have been studied to this time, therefore, did not result in irradiated concentrated milk of adequate storage life at or above room temperature.

It has been demonstrated that the storage characteristics may be improved by means of corrective measures being taken before or after the irradiation. Small amounts of sulphur dioxide reduce the development of browning. The gelling time has been shown to be prolonged by addition of small amounts of calcium ions. Sulfhydryl compounds such as cysteine, thioglycollic acid and dithioglycerol have, in preliminary tests, been shown to be efficient in altering the tendency towards gelation. Colloid stabilizers on the other hand, seem to have little effect.

In summary, it may be concluded that the cold sterilization of milk may result in a concentrated product of adequate storage life at room temperature or higher only if means are found to prevent the development of browning and of gelation in storage. The effect of small amounts of sulfite and sulfhydryl compounds added to the milk before the irradiation indicated that such means may be found.

Acknowledgment

The authors are appreciative of financial assistance in the form of grants-in-aid from the following organizations which made a part of this program possible: Armour and Company, Carnation Company, The Nestlé Company, and Oscar Mayer and Company.

The Department is grateful to the General Electric X-ray Department for making available the 1 M.e.v. resonant transformer used in these studies.

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Factors Affecting Quality of Prepackaged Meat

IV. Microbiological Studies. C. Effects of Initial Bacteria Count, Kind of Meat, Storage Time, Storage Temperature, Antioxidants, and Antibiotics on the Rate of Bacterial Growth in Packaged Meat[a,b]

(Manuscript received March 20, 1956)

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Departments of Food Science and Animal Husbandry, Rutgers University, New Brunswick, New Jersey

Factors influencing bacterial growth in prepackaged meat, the kinds of microorganisms which grow at the temperatures used, and the relationship between bacterial growth and color changes in prepackaged meat were of specific concern in the microbiological part of this investigation. The present study considered the influence on bacterial growth of the kind of meat, the initial bacterial count, and the application of antibiotics and antioxidants. Packaging conditions, storage time and temperature were, as in previous studies in this series, the basic variables.

PROCEDURES

Since the procedures have been defined in previous studies[d] it will suffice to include here only the packaging conditions and code numbers.

RESULTS

Figures 1 through 8 show how bacterial growth was affected by the source and initial numbers of bacterial cells, by storage temperature, and by treatment of the meat with antioxidants and antibiotics. Table 1 presents the effects of various antibiotics on ground fat pork.

Package Types

Code no.	Packaging material
2	Can
3	Unpackaged
4a	Vinylidene copolymer (Cry-O-Vac)
6	MSAT86 cellophane, coated both sides
6a	MSAT80 cellophane, coated side inside
6d[1]	MSAT80 cellophane, coated side outside
6w[1]	MSAT80 cellophane, coated side outside (wrapped)
8[2]	Cellulose acetate P-912
10[2]	Polyethylene
15	Cellophane-pliofilm laminate, pliofilm inside
16	Cellophane-polyethylene laminate, polyethylene inside
17	Cellulose acetate-pliofilm laminate, pliofilm inside
20	Trithene (wrapped)

[1] "Hand" made in the laboratory.

[2] "Hand" made by Celanese Corporation; all other film packages except No. 20 were "factory" made by Standard Packaging Corporation.

DISCUSSION

The factors which were considered in relation to the bacterial growth on prepackaged meats were storage time, temperature, packaging conditions, kinds of meat, initial bacterial count, antibiotics, and antioxidants.

Storage time.

The following observations were made on prepackaged meats stored for one month at 34° to 38° F.

1. The specific effects exerted by the different pack-

[a] A report of work conducted by contract with the Bureau of Animal Industry, U. S. Department of Agriculture, with funds provided under the Research and Marketing Act.

[b] A paper of the Journal Series, N. J. Agricultural Experiment Station, Rutgers University, the State University of New Jersey, Departments of Food Science and Animal Husbandry, New Brunswick, N. J.

[c] Data from Ph.D. thesis of Frank E. Halleck.

[d] See *Food Technol.*, 12, 301 (1958).

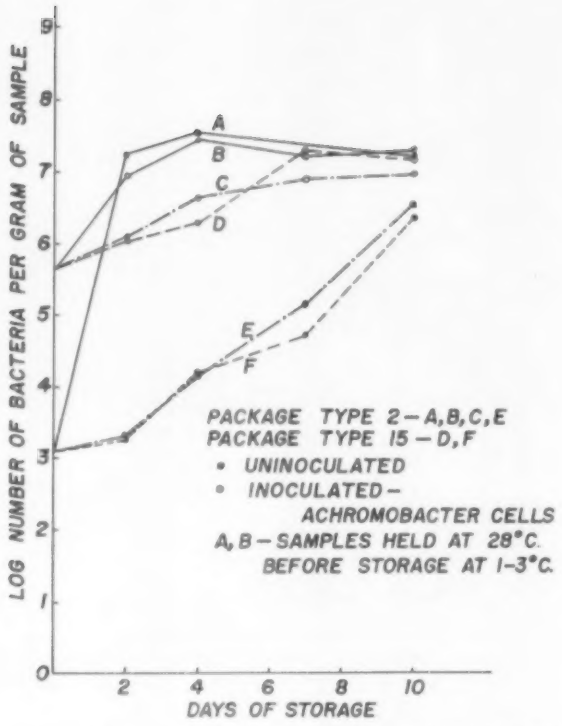

Figure 1. Mean total bacteria counts in uninoculated and non-pigmented Achromobacter-Pseudomonas inoculated fat ground lamb in package types 2 and 15 stored at 34–38° F. (Run P).

TABLE 1

Effect of various antibiotics on bacterial growth in nonpackaged fat ground pork stored at 40–44° F. (Run T)

	Antibiotic concentration γ/g	Total bacteria count	Non-pigmented *Achromobacter Pseudomonas* type	*Lactobacillus*
0 Days		5.01×10^4	3.41×10^4	4.83×10^3
Neomycin				
2 Days	I–(95.5)	1.15×10^6	8.44×10^5	3.07×10^6
	II–(175)	8.10×10^6	5.10×10^5	3.00×10^6
4 Days	I–(95.5)	2.58×10^8	2.08×10^8	5.10×10^7
	II–(175)	3.25×10^8	2.83×10^8	4.27×10^7
7 Days	I–(95.5)	1.96×10^9	1.81×10^8	1.54×10^8
	II–(175)	8.50×10^8	7.71×10^8	7.98×10^7
Streptomycin				
2 Days	I–(403)	7.79×10^4	3.98×10^4	3.81×10^4
	II–(108)	8.50×10^5	3.91×10^5	4.88×10^5
4 Days	I–(403)	1.22×10^7	6.94×10^6	4.71×10^6
	II–(108)	1.20×10^8	9.25×10^7	1.75×10^7
7 Days	I–(403)	7.13×10^7	4.95×10^7	2.18×10^7
	II–(108)	1.53×10^9	1.27×10^9	2.50×10^8
Bacitracin				
2 Days	I–(105)	2.17×10^6	2.09×10^6	8.43×10^4
	II–(122)	1.97×10^6	1.32×10^6	6.52×10^5
4 Days	I–(105)	3.53×10^8	2.94×10^8	5.85×10^7
	II–(122)	4.41×10^8	3.48×10^8	9.33×10^7
7 Days	I–(105)	3.36×10^9	3.10×10^9	2.54×10^8
	II–(122)	2.20×10^9	1.94×10^9	2.58×10^8
Penicillin				
2 Days	I–(161)	9.82×10^4	8.06×10^4	1.40×10^4
	II–(138)	1.18×10^5	1.12×10^5	6.38×10^3
4 Days	I–(161)	1.92×10^7	1.44×10^7	4.95×10^6
	II–(138)	1.00×10^7	9.15×10^6	9.10×10^5
7 Days	I–(161)	1.97×10^9	1.63×10^9	3.37×10^8
	II–(138)	9.10×10^8	8.20×10^8	9.10×10^7
Combinations				
2 Days	I–†	1.71×10^6	1.55×10^6	1.62×10^5
	I–‡	1.64×10^6	7.63×10^5	8.80×10^5
4 Days	I–†	2.56×10^8	1.76×10^8	8.08×10^7
	I–‡	3.02×10^8	2.41×10^7	6.33×10^7
7 Days	I–†	1.46×10^9	1.15×10^9	3.88×10^8
	I–‡	9.78×10^8	9.10×10^8	6.70×10^7
Control				
2 Days		2.92×10^6	2.69×10^5	2.32×10^5
4 Days		4.93×10^8	3.96×10^8	9.80×10^7
7 Days		1.62×10^9	1.46×10^9	1.52×10^9

† Penicillin, 83.5 γ/g.; Bacitracin, 22.5 γ/g.
‡ Penicillin, 3.3 γ/g.; Bacitracin, 2.25 γ/g.

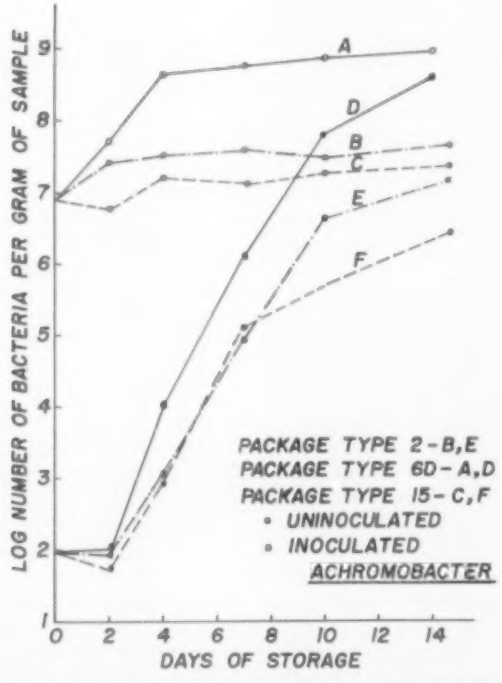

Figure 2. Mean total bacteria counts in fat ground pork in package types 2, 6d, and 15 stored at 40–44° F. (Run S).

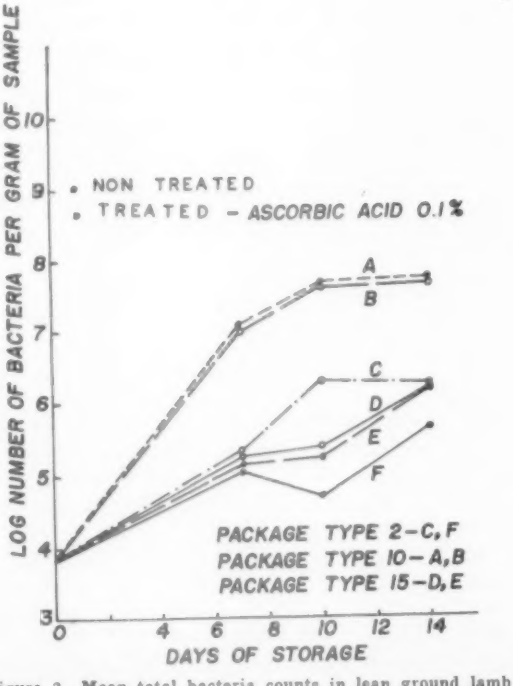

Figure 3. Mean total bacteria counts in lean ground lamb in package types 2, 10, and 15 stored at 37–41° F. (Run U).

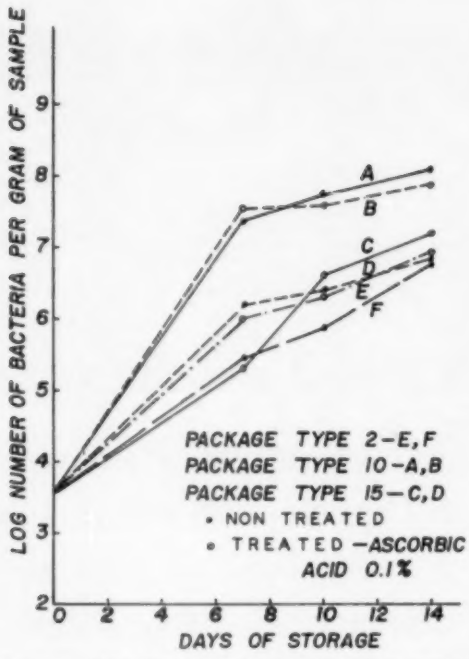

Figure 4. Mean total bacteria counts in lean ground lamb in package types 2, 10, and 15 stored at 37–41° F. (Run U).

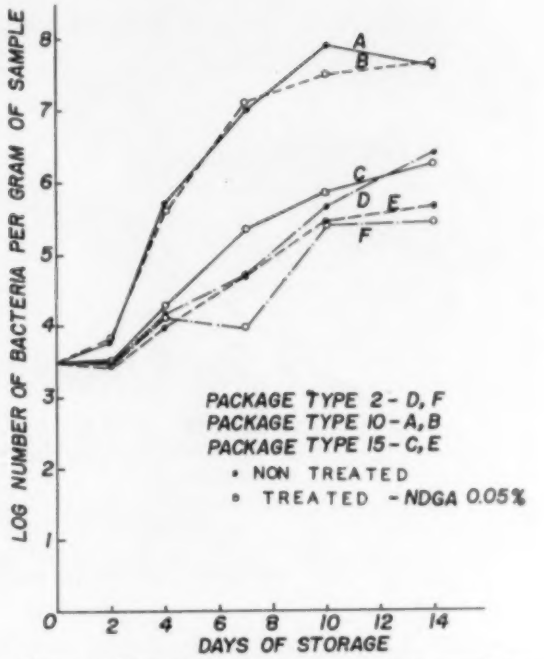

Figure 5. Mean total bacteria counts in lean ground lamb in package types 2, 10, and 15 stored at 37–40° F. (Run V).

aging materials on bacterial growth vary with time (Runs H, M, N, and O).*

2. The initial bacteria count of the meat influences both the rate of bacterial growth and the duration of active bacterial growth (Runs H, M, N, and O).

3. Bacterial growth in prepackaged meat proceeds to a population maximum, which is not necessarily unique for each packaging material (Runs M, N, and O).

4. The *Achromobacter pseudomonas fluorescens* type organism is an important component of the bacterial flora of fresh meat in the latter part of the storage period (Runs M, N, O, and R).

The following observations were made on prepackaged meats stored for two weeks at 34° to 38° F. or 40° to 44° F.

1. For the first two days of storage there is a lag in bacterial growth in most of the packaging materials (Runs P, R, S, U, and V).

2. After the second day of storage bacterial growth usually occurs irrespective of the storage temperature or packaging material (Runs P, R, S, U, and V).

3. Increasing the storage temperature from 34° to 38° F. and 38° to 44° F. accelerated the rate of bacterial growth, but did not shorten the two-day lag period (Runs R, S, U, V).

4. The time at which the bacterial population maximum is attained in the meat appears to be related to the gas-water vapor permeability of the packaging material and to the presence of mold growth (Runs P, R, S, U, and V).

5. Increasing the initial bacteria count by inoculation with non-pigmented *Achromobacter pseudomonas* cells resulted in earlier population maxima of similar magnitude to those of non-inoculated material (Runs P and S).

Storage temperature.

Bacterial growth in prepackaged meats was usually slow enough at 34° to 38° F. to permit the evaluation of the specific effects exerted by the various packaging materials. However, if the initial population was high (Run M), the maxima were attained before the first scheduled examination of the samples, and evaluation of the package types in this respect was not possible.

At 40°–44° F. the rate of bacterial growth was almost twice as rapid as at 34°–38° F. (Figures 2–6, inclusive). Active bacterial growth did not occur at either temperature for the first two days of storage. The only exceptions were found with polyethylene (10) and cellophane (6d) packaged meats (Figures 3, 6, and 2, respectively). At the higher temperature, the *Achromobacter-Pseudomonas fluorescens* type was found at 7 days instead of 14 days.

At the higher storage temperature microbiological examinations were made at shorter intervals and the population maxima were reached between 10 and 14 days of storage (Figures 5 and 6). The bacterial maxima in a given packaging material were approximately the same at both storage temperatures.

Influence of the initial bacteria count on bacterial growth in prepackaged meat. Effect of the initial bacteria count on bacterial growth in prepackaged meat is apparently influenced by storage temperature and the time at which the examinations are made, in

* See *Food Technol.*, 12, 197 (1958).

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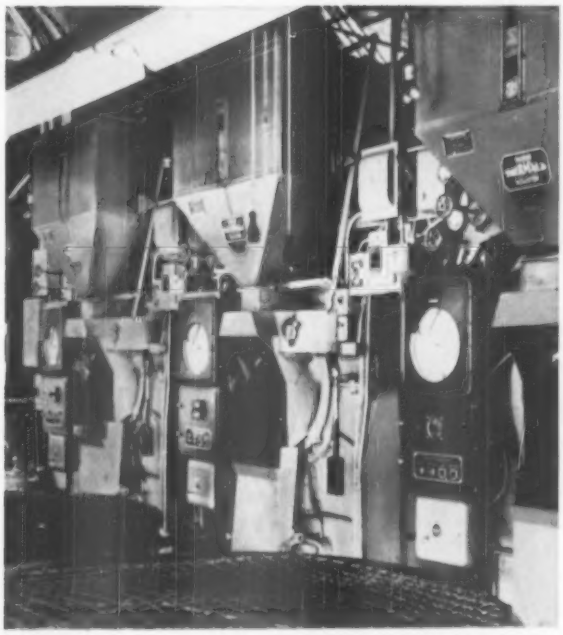

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INSTRUMENTATION FOR THE FOOD INDUSTRY

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addition to other factors. For example, in Run M (Figure 2, Section IV-A),[4] the initial bacteria count of the fat ground pork was 450 thousand cells per gram of meat and active bacterial growth took place in the meat in packages 2, 15, and 17 prior to the 7th day of storage at 34–38° F. The mean bacteria counts were all the same at the first examination on the 7th day of storage, therefore no evaluation on the specific effects of the packaging materials could be made. To ascertain the effect of the initial bacteria counts it was necessary to make the microbiological examinations early in the storage period. Since the population maxima were the same for the different packaging materials, data on the influence of packaging materials on bacterial growth had to be obtained before the population reached a maximum.

Bacterial growth rate in the non-pigmented *Achromobacter pseudomonas* inoculated meat packaged in film 15 (Runs P and S, shown in Figures 1 and 2 and Table 2) was not substantial. Initial bacteria count on inoculated meat was higher than the population maximum attained in uninoculated meat packaged in film 15. When the initial bacteria count is high, a comparison of the rates of bacterial growth may not necessarily show the true influence of the packaging materials on the growth rate. Data from the inoculated packaged meats indicated that the non-permeable films permit only a limited bacterial population in the meat.

In Run H, the initial bacteria count of the ground beef was about 10 thousand cells per gram. Active bacterial growth took place throughout the 21-day storage period (Figure 1, Section IV-A and Table 1, Section IV-A).[5] Since the numerical differences throughout the storage period between the mean bacteria counts of the different types of packages were statistically significant, an evaluation of the specific effects exerted by the packaging materials could be made.

Slight increases in the mean bacteria counts took place during storage of the non-pigmented *Achromobacter-Pseudomonas* inoculated meat samples, and the increases were dependent on the specific bacterial population maxima that could be supported by the various packages. For example, in Run S (Figure 2 and Table 2) inoculated ground pork packaged in film

[4] See *Food Technol.*, 12, 197 (1958).

TABLE 2

Significance of difference (calculated "t" values[1]) between total bacteria counts, ground pork (Run S)

Uninoculated samples			Non-pigmented *Achromobacter-Pseudomonas* group inoculated samples		
Package type	6d	15	Package type	6d	15
2 Days			2 Days		
2	0.456	2.02	2	1.27	3.45
6d		1.54	6d		2.27
4 Days			4 Days		
2	1.35	0.259	2	2.52	1.60
6d		1.38	6d		2.51
7 Days			7 Days		
2	4.09	1.04	2	3.00	9.84
6d		3.98	6d		3.15
10 Days			10 Days		
2	1.70	2.48	2	2.70	4.80
6d		1.80	6d		2.74
14 Days			14 Days		
2	2.99	1.25	2	1.73	3.17
6d		3.07	6d		58.5

[1] Calculated "t" values should exceed 1.81 to have significance. See Johnson, P. O. *Statistical Method.* 1949.

[5] See *Food Technol.*, 12, 197 (1958).

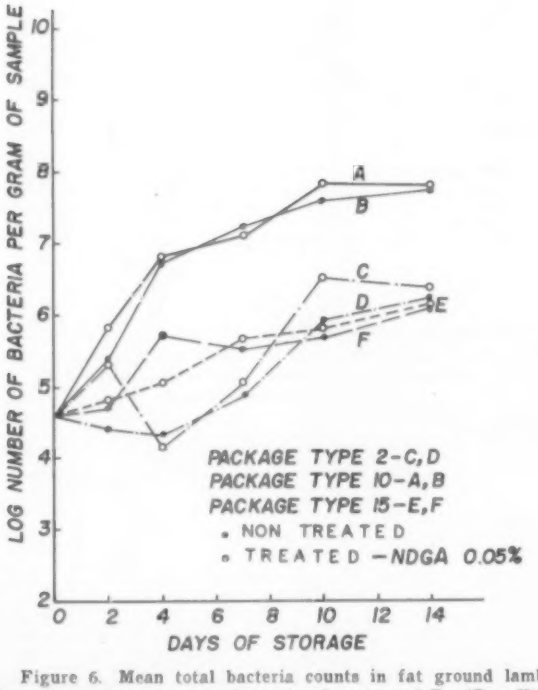

Figure 6. Mean total bacteria counts in fat ground lamb in package types 2, 10, and 15 stored at 37–40° F. (Run V).

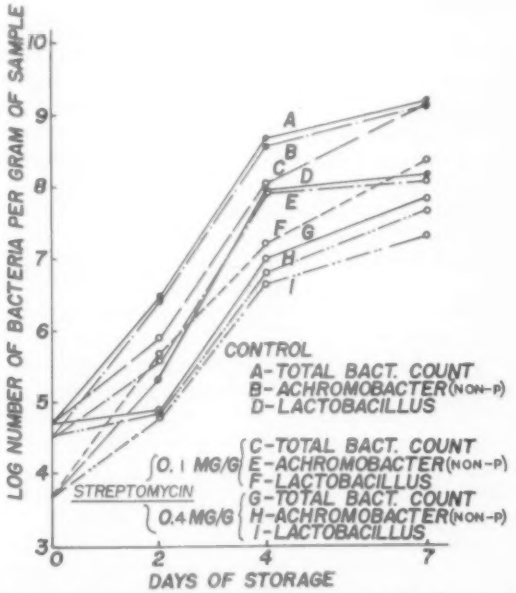

Figure 7. Effect of streptomycin on the rate of bacterial growth in nonpackaged fat ground pork stored at 40–44° F. (Run T).

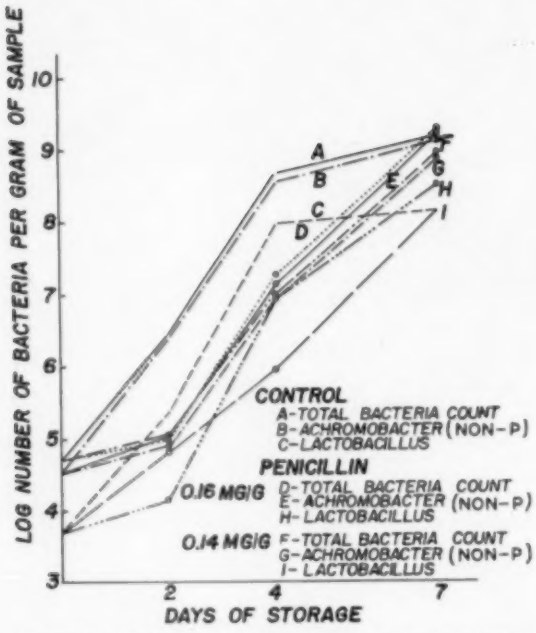

Figure 8. Effect of penicillin on the rate of bacterial growth in nonpackaged fat ground pork stored at 40–44° F. (Run T).

6d had a 10-fold increase in the mean bacteria counts during the first four days of storage at 40–44° F. No further growth was found during subsequent storage which indicated that the population maximum was attained in package 6d at the fourth day of storage. Little bacterial growth took place in the nonpigmented *Achromobacter-Pseudomonas* inoculated meat in packages 2 and 15 in Run S; the initial bacteria count was higher than the maxima attained in uninoculated meat in these packages.

In Run P, three types of can-packaged meat were studied concurrently: (1) non-pigmented *Achromobacter-Pseudomonas* inoculated, stored immediately at 34–38° F., (2) noninoculated, held for 20 hours at 82.4° F. before storage at 34–38°F., and (3) nonpigmented *Achromobacter-Pseudomonas* inoculated, held for 20 hours at 82.4° F. prior to storage at 34–38° F. Figure 1 shows that the population maximum was the same with the three types of can-packaged samples. The population maximum attained in all can-packaged meat was dependent solely upon the specific effects exerted by the packaging material on bacterial growth.

The initial bacteria count was found to be unimportant with respect to bacterial growth in unpackaged meat (Run T; Table 1 and Figures 7 and 8), since bacterial growth took place throughout the storage period.

Influence of the kind of meat on the rate of bacterial growth in prepackaged meat. Apparently the kind of meat does not have an influence on bacterial growth in prepackaged meats, since no significant differences were found between the bacteria counts obtained from beef, lamb, or pork.

Leanness or fatness of the meat apparently did not influence the rate of bacterial growth (Figure 1 and Table 1),[h] but the initial counts obtained from a fatty meat usually were tenfold higher than those from lean meat.

Influence of antioxidants on bacterial growth in prepackaged meat. Data presented in Tables 4 and 6 and in Figures 3 through 6 show the changes in the mean total bacteria counts of nontreated and antioxidant treated lean and fat ground lamb, packaged in the can *(2)*, film 10, and film 15 during a 14- and 15-day storage period at 37–41° F. Data of Run U were suggestive that ascorbic acid had an effect on bacterial growth in meat, but a statistical analysis of the data showed that the difference between the mean bacteria counts of the treated and nontreated samples was not significant. In Run V (Table 6 and Figures 4 and 5) the data showed that the addition of nordihydroguaiaretic acid did not influence bacterial growth.

Influence of antibiotics on bacterial growth in meat. In Run T, the influence of antibiotics on the rate of growth in mixed lean and fat ground pork was

[h] See *Food Technol.*, 12, 197 (1958).

TABLE 3

Significance of difference (calculated "t" values[1]) between total bacteria counts of different packaging conditions (Run U)

Storage	Lean—untreated			Mixed lean and fat—untreated	
	Package type	10	15	10	15
7 Days	2	2.41	0.226	2.79	0.815
	10		2.41		2.64
10 Days	2	5.01	1.14	1.24	1.27
	10		5.16		1.20
15 Days	2	5.54	2.97	2.17	0.711
	10		41.0		2.16
	Lean—antioxidant treated[2]			Mixed lean and fat—antioxidant treated[2]	
7 Days	2	2.00	1.06	3.97	1.61
	10		2.01		4.07
10 Days	2	2.32	1.70	6.75	0.798
	10		30.3		6.21
15 Days	2	7.39	0.002	4.57	2.30
	10		7.43		4.11

[1] Calculated "t" values should exceed 2.02 to have significance. See Johnson, *op. cit.*

[2] Ascorbic acid was the antioxidant.

TABLE 4

Significance of difference (calculated "t" values[1]) between the mean total bacteria counts of the untreated and the antioxidant (ascorbic acid) treated ground lamb at each examination time (Run U)

Time	Lean samples		
	Package type		
	2	10	15
(days)			
7	0.509	0.286	0.199
10	1.89	0.827	0.545
14	1.42	1.21	0.202
	Mixed lean and fat samples		
7	1.41	0.865	1.21
10	0.990	0.159	1.12
14	0.778	0.379	3.76

[1] Calculated "t" values should exceed 2.02 to have significance. See Johnson, *op. cit.*

TABLE 5

Significance of difference (calculated "t" values[1]) between mean bacteria counts from meat under different packaging conditions (Run V)

Storage	Lean—untreated			Mixed lean and fat—untreated	
	Package type	10	15	10	15
2 Days	2	4.59	0.487	2.46	2.26
	10		4.26		2.22
4 Days	2	3.16	1.54	5.05	1.24
	10		3.17		4.28
7 Days	2	2.12	3.29	3.60	2.40
	10		1.68		3.54
10 Days	2	2.62	0.473	4.20	0.624
	10		3.19		4.24
14 Days	2	1.41	1.73	.....	0.68
	10		17.0		.....
	Lean—antioxidant treated[2]			Mixed lean and fat—antioxidant treated[2]	
2 Days	2	5.72	0.003	1.60	0.929
	10		4.60		2.23
4 Days	2	1.84	0.649	5.60	2.40
	10		1.81		5.52
7 Days	2	3.31	2.11	3.52	1.61
	10		3.26		3.42
10 Days	2	8.04	0.700	3.44	1.48
	10		7.94		3.57
14 Days	2	6.94	1.09	7.94	2.22
	10		6.68		8.08

[1] Calculated "t" values should exceed 2.02 for significance: Johnson, *op. cit.*

[2] NDGA was the antioxidant.

TABLE 6

Significance of difference (calculated "t" values[1]) between the mean total bacteria counts of the untreated and antioxidant treated ground lamb (Run V)

Time	Package type		
	2	10	15
(days)			
Lean samples			
2	0.969	0.423	0.924
4	0.091	0.438	1.85
7	4.15	0.617	3.00
10	0.387	1.45	0.715
14	1.36	0.481	1.10
Mixed lean and fat samples			
2	1.23	1.09	0.901
4	0.913	0.913	1.00
7	0.922	0.449	0.508
10	1.32	1.57	1.06
14	0.490	.....	0.101

[1] Calculated "t" values should exceed 2.02 to have significance: Johnson, *op. cit.*

studied. Table 1 shows the mean bacteria count from the nontreated and the antibiotic treated meat during a 7-day storage period at 40–44° F., Bacitracin and Neomycin at the concentrations tested did not affect the rate of bacterial growth in the ground meat. The proportions of the components of the bacterial flora also were not changed.

An effect on the rates of bacterial growth was found with Streptomycin and Penicillin (Table 1 and Figures 7 and 8). A lag in bacterial growth occurred during the first 2 days of storage.

Figure 7 shows that 0.11 mg. of Streptomycin per gram of meat did not limit growth as much as 0.40 mg. The inhibition of bacterial growth by the antibiotics was not effective beyond the second day of storage.

With Penicillin the inhibition of bacterial growth was overcome by the second day of storage and bacterial growth progressed at the same rate as in untreated samples. There was no essential difference in the amount of inhibition observed at the 2 concentrations used. Proportions of the components of the bacterial flora were not altered by the addition of penicillin to the meat.

The use of the antiobiotics which were tested, as a means of controlling bacterial growth, is limited, since the inhibition period is only 2 days.

SUMMARY

Bacterial growth was not influenced by the kind of meat (beef, lamb or pork). However, the proportion of fat and lean did have an effect. Fat ground meat was apparently a better substrate than lean ground meat.

Antioxidants (ascorbic acid and nordihydroguaiaretic acid) did not influence the growth of bacteria during a 14 day storage period at 40–44° F.

The antibiotics, Bacitracin and Neomycin, in unpackaged meat, did not influence bacterial growth. High concentrations of Streptomycin and Penicillin inhibited growth for only the first two days of storage at 40–44° F.

Effect of Antibiotic Treatment on Storage Life of Turkeys[a]

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(Manuscript received May 31, 1958)

WITH THE CURRENT USE of antibiotics, chlorine, and other sanitizing agents in poultry processing, there is need for investigating the possible application of these antimicrobial agents to small-scale processing conditions. The literature on the use of antibiotics in preserving poultry meat has become rather voluminous in recent years, although relatively little work has been reported concerning preservation of turkey meat by this method. Windlan *et al. (10)* found that the storage life of turkeys, similar to that of chickens, was extended by processing with chlortetracycline.

The present study was initiated to evaluate the effects of preservative agents on poultry processed on a small-scale. The work reported here is confined to methods of application of chlortetracycline and chlorine to turkey processing. In addition to keeping quality, consideration was given to differences in water absorption by the birds.

PROCEDURE

Large broad-breasted white turkeys and Beltsville Small White turkeys, reared at the Research Center, were killed at 13 and 16 weeks of age, respectively. The turkeys were scalded at 140° F. (60° C.) for 30 seconds and the feathers were removed by a mechanical picker. Dressed birds treated with approximately 20 p.p.m. chlortetracycline were held in the antibiotic-ice solution in chill tanks overnight; after evisceration, some turkeys were given an additional terminal dip in chlortetracycline prior to packaging. Chlorine, at a level of 20 p.p.m. (70% available chlorine) was applied to other turkeys in separate chill tanks. Control birds were not subjected to antibiotic or added chlorine. All turkeys were packaged in Cry-O-Vac[c] bags and stored at 35–38° F. (1.7–3.3° C.).

The amount of chill solution absorbed by the carcasses was determined after birds were removed from the chill tanks and drained. In addition, other trials were conducted using half-chickens for evaluation of uptake of water by the tissues. In the latter experiments, all half-chickens were dipped in slush ice solutions containing ingredients in proportions similar to those of the commercial Acronize mixture, a slush ice solution of Acronize, and a control solution of ice and water.

Skin surfaces were sampled at various time intervals for bacterial counts, using the swab technique described by Ayres, Ogilvy, and Stewart *(2)*, with the exception that the swabbed areas were 0.5 sq. in. (3.2 sq. cm.). The swab method was observed by Ayres *et al. (3)* to yield consistently higher counts than the rinse method. In initial work, plating media included fluorescein agar *(6)*, nutrient agar, trypticase soy agar, and eugonagar. Later, enumeration of total organisms was made using only trypticase soy agar. No selective medium was employed for plating yeasts and molds, but changes in populations of these organisms were noted. Plates were incubated at 30° C. for 3 days.

Chlortetracycline was determined by a modification of the method described by Grady and Williams *(5)* and similar to that reported by Ayres *et al. (3)*. Antibiotic assay disks were dipped in pH 4.5 phosphate buffer, drained, and then placed on the skin surface of the turkey. The amount of antibiotic recovered by this procedure was greater that that obtained without first saturating the assay disks in buffer solution. For assays of antibiotic present in the water of chill tanks, the microbiological assay method and the fluorometric technique of Levine, Garlock, and Fischbach *(8)* were employed. However, when acid-acetone extracts of the skin and flesh of antibiotic treated birds were compared with those of control birds by the fluorometric method, assay results were similar. Therefore, the fluorometric method was not used for determinations of residual antibiotic on the turkeys. Standard curves were prepared according to an adaptation of the procedures recommended by the Food and Drug Administration *(1)*.

The technique reported by Cotterill *(4)* for determining spoilage of poultry by appearance under ultraviolet light was also used to a limited degree. For these tests, the whole carcasses and pieces of cut-up turkey were examined. Fluorescein medium was swabbed on the surfaces of some of the turkey meat samples; part of these were inoculated with a fluorescent pigment-producing strain of *Pseudomonas* previously isolated from spoiled chicken. Other samples had no added inoculum and control portions were neither inoculated nor treated with fluorescein medium. All turkey samples were stored as described previously.

RESULTS AND DISCUSSION

Changes in bacterial numbers on the skin surfaces of the turkeys are shown in Figure 1. Initial bacterial counts on the flesh and skin of the birds were approximately 1000 organisms per sq. cm. With low initial bacterial populations, the effectiveness of the antibiotic treatments might be expected to be greater than noted with high original counts. The level of microorganisms indicated here is not intended to be representative of commercial conditions, but is typical of the small-scale processing operation conducted at Beltsville. Microbial populations on control birds increased to greater numbers than those on birds subjected to either of the chlortetracycline treatments. Off-odor was apparent on control turkeys after storage for 27 days, whereas surface bacterial counts did not increase appreciably during that time on turkeys chilled in chlortetracycline. At the end of about 40 days in storage, off-odor developed on birds treated with Acronize in the chill tank while N. Y. dressed. Keeping time was approximately 45 days for birds chilled in an Acronize solution as N. Y. dressed, and then given an additional dip in antibiotic after evisceration.

With regard to storage life, care must be exercised in interpretation of these data. It was not intended that the use of antibiotics be "pyramided" in poultry

[a] Presented at the Eighteenth Annual Meeting of the IFT, Chicago, Ill., May 28, 1958.

[b] Present address: Eastern Utilization Research and Development Division, Agricultural Research Service, U.D.S.A., Beltsville, Md.

[c] Mention of this and other brand names does not imply their endorsement by the U. S. Department of Agriculture.

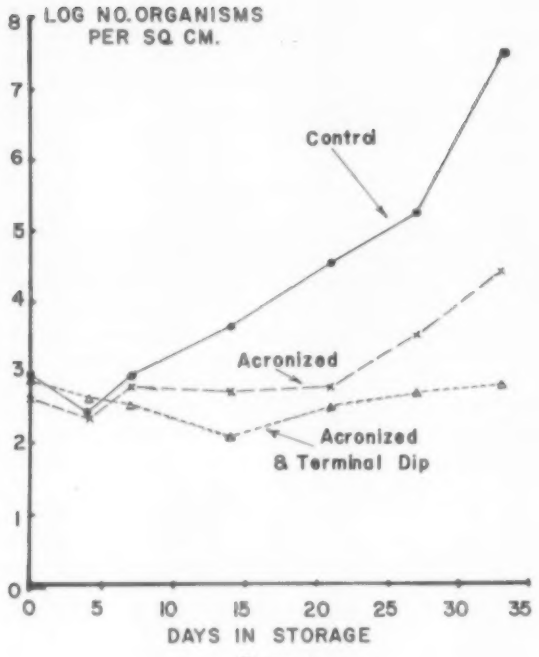

Figure 1.

processing by adding one treatment to another. It is recognized that birds receiving the second antibiotic dip were exposed to chlortetracycline for a longer period than were turkeys subjected to only one antibiotic treatment. However, no data were obtained to indicate that the combined treatment resulted in chlortetracycline levels higher than the allowable tolerance for uncooked poultry. The second chlortetracycline dip was given to eviscerated turkeys in order to evaluate the effect of preservative measures after more cut surfaces may presumably be exposed to contamination *(9)*. In later work, wherein a single dip in chlortetracycline was given to eviscerated turkeys, bacterial counts were comparable to those on eviscerated turkeys similarly treated while in the New York dressed condition. Therefore, it is likely that the greater reduction in surface organisms on birds receiving the antibiotic dip before and after evisceration was due to the additional antibiotic and not solely a result of decrease in contamination of cut surfaces (Figure 1). Kohler *et al. (7)* compared methods of application of chlortetracycline and found no significant differences in keeping time when the antibiotic was used on eviscerated or cut-up chickens.

Another consideration in methods of application concerns the large number of poultry processors employing warm evisceration, whereby antibiotic may be applied during chilling after evisceration. Use of antibiotic in this manner might be expected to counteract, in some measure, contamination on freshly exposed surfaces after evisceration.

In a single trial with 20 p.p.m. residual chlorine in the chill tank, numbers of organisms were lower on chlorine-treated birds than on control turkeys during the first week of storage. Subsequently, however, bacterial populations were similar to those on control birds. Little difference was noted with regard to time for development of off-odor. Chlorine did not maintain bacterial numbers at as low a level as did chlortetracycline during storage of turkeys for one month.

Examination of whole carcasses and pieces of turkey meat under ultraviolet light did not reveal fluorescence until deterioration was well advanced. Fluorescent areas generally became evident shortly after off-odor and slime were observed. Addition of fluorescein medium to the skin surfaces did not appear to enhance production of fluorescence or decrease the time for it to become visible.

Decreases in concentrations of chlortetracycline on the skin of stored turkeys are shown in Figure 2. Initial samples were taken about 3 hours after the birds were removed from chill tanks containing approximately 20 p.p.m. chlortetracycline. Possibly, determinations of the original levels of antibiotic on the skin may have been greater if the assays were performed immediately after the birds were drained. Although a rapid decrease in concentration occurred during storage, antibiotic was still detected at the end of 33 days. Levels of chlortetracycline were higher on the skin of turkeys subjected to the dip before and after evisceration than on birds given a single treatment during chilling.

In several instances, considerable variation was noted in antibiotic concentrations on different parts of the same bird, or among different birds. This was true for the acid-acetone extraction procedure and for the method wherein assay disks were placed on the skin surface of the turkeys. Variations in amount of antibiotic in different parts of turkeys dipped in chlortetracycline have been reported by Windlan *et al.*

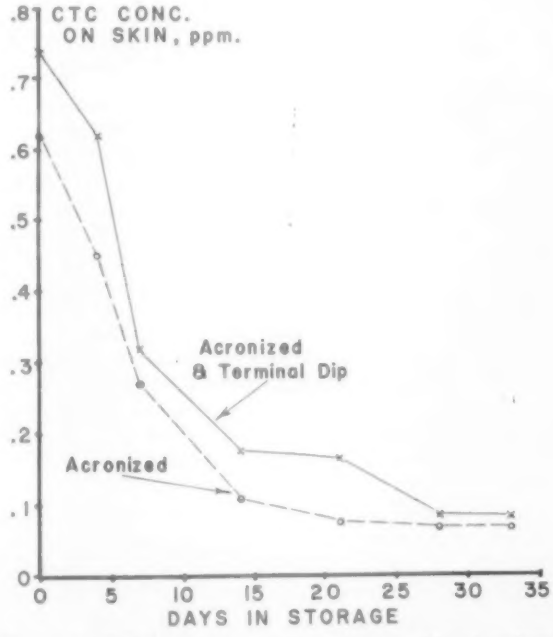

Figure 2. Chlortetracycline concentrations on skin of turkeys.

(10); these workers observed a range of 0 to 1.0 γ per g. in the tissues.

When pieces of skin from antibiotic-treated birds were placed on seeded agar plates, zones of inhibition were larger than those around assay disks having the same surface area as the skin samples. Diameters of zones surrounding the pieces of skin were generally about 10 mm. greater than zones around the assay disks. However, because of the difficulty in producing a circular skin sample comparable to the assay disks, determinations of zone size could not be standardized for comparison with a standard curve. Therefore, the direct skin assay was employed for qualitative, rather than quantitative, estimates of antibiotic present on the surface of the turkeys.

During the course of this work, it was observed that turkeys treated with commercial food grade chlortetracycline demonstrated greater increases in weight during chilling than did the control birds. The mean value was 3.8% weight grain for control turkeys chilled in slush ice for 24 hours, as compared with 5.1% for birds given a single dip in Aeronize-ice solutions, and 5.9% for turkeys chilled in a similar antibiotic solution before and after evisceration. In the experiments utilizing half-chickens dipped in various solutions, the Aeronize solution and a solution of 80 p.p.m. NaCl were similar in effect on weight gains (See Table 1). Since the commercial Aeronize mixture

TABLE 1

Percent gain in weight of half-chickens immersed in various chill solutions

Chill Solution	Hours in Chill Solution				
	2	3	4	5	24
10 p.p.m. CTC	5.7	8.2	8.8	9.8	13.1
100 p.p.m. Acronize	5.2	6.2	7.0	8.0	12.4
80 p.p.m. NaCl	4.7	6.0	7.3	8.0	10.8
10 p.p.m. Citric Acid	2.9	3.7	4.7	6.2	10.5
Control (Slush Ice)	2.6	3.6	4.4	4.7	8.3

contains approximately 80% salt, it might be expected that this component and the Acronize mixture would produce similar effects with regard to water absorption by the tissues. A chill solution containing 10 p.p.m. purified chlortetracycline produced the greatest percent weight gain of the materials tested. No attempt was made to determine the mode of action of the antibiotic on absorption of liquid by the poultry meat. Citric acid at a concentration of 10 p.p.m. did not differ appreciably from the control ice solution with regard to percent weight gain of half-chickens during the first 4 hours of chilling. From these data, it may be noted that all materials similar to the components of the commercial Aeronize mixture effected greater increase in weight than that observed for the control slush ice solution.

An observation of interest concerned the inhibitory action of the skin of turkeys processed at 140° F. (60° C.). Spores of *Bacillus cereus* var. *mycoides* (ATTC 11778), the chlortetracycline assay organism, were inhibited in growth by the skin of sub-scalded control birds. This observation was variable in its incidence; it was not noted with turkeys scalded at 126° F. (52.2° C.) or with sub-scalded chickens. Further, it did not always occur with turkeys processed at the higher temperature. In no instance was there any inhibition of the strain of *Pseudomonas* employed in these studies.

SUMMARY

Chlortetracycline provided an increase in storage life of turkeys when used as a single dip in the chill tank while birds were in the N. Y. dressed condition. With a second dip after evisceration, the keeping time of turkeys was increased further. Chlorine was not as effective as the antibiotic in retarding spoilage. The use of commercial poultry dip chlortetracycline mixture produced greater percent weight gains after chilling than observed with control birds; this was due largely to the antibiotic and the salt in the mixture.

The skin of untreated control turkeys processed at 140° F. (60° C.) exerted an inhibitory effect against the chlortetracycline assay organism.

Acknowledgment

Appreciation is expressed to Edgar Quillin and A. W. Schneider for their assistance in the laboratory, and to J. S. DiLorenzo and Frances Bowman of the Food and Drug Administration for supplying cultures of *B. cereus* var. *mycoides* and chlortetracycline.

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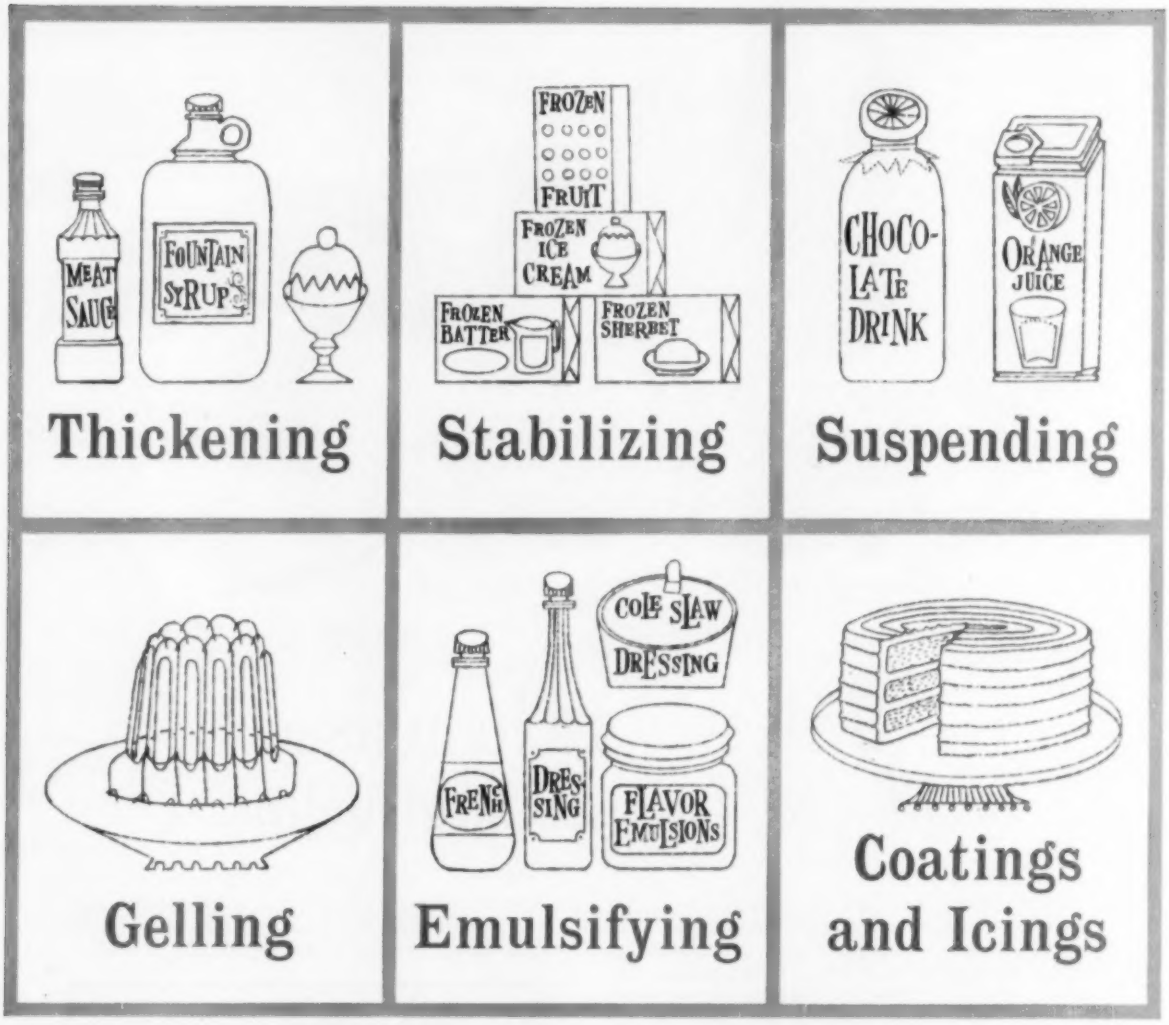

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Effect of Storage Conditions on the Color of Frozen Packaged Retail Beef Cuts[a,b,c]

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(Manuscript received May 31, 1958)

THE EFFECT OF PROCESSING and storage conditions (temperature and display under light) was studied. Storage conditions, especially temperatures and type of light have a marked effect on the stability of color in packaged frozen retail beef cuts. Meat color was measured objectively by two different methods.

Myoglobin, the muscle pigment, is chiefly responsible for the color of lean meat, which under various conditions changes from oxymyoglobin (the desirable red color) to metmyoglobin (the brownish red color so characteristic of meat color degradation). The color of frozen meat varies from a very dark color due to slow freezing, to a complete loss of color when plate frozen at −50° F. *(12)*. Satisfactory color is achieved when freezing is done by the blast method at −10° F. *(5)*. At 14° F., Brooks *(2)* found no visible discoloration of lean meat stored for sixteen weeks. At 29.5° F. there was no discoloration owing to the formation of methemoglobin until 40–50 days from killing. Ramsbottom *(10)* stored fresh beef in darkness at six different temperatures ranging from −20° F. to +26° F. packaged in DuPont 300 M.S.A.T. No. 87 cellophane. The product was discolored in 30 days at 26° F., whereas in the product stored at −20° F. color and appearance were still good after one year's storage. Tressler and Evers *(13)* stated that frozen meat changes in color from the red to brown color at a higher temperature of storage. Ramsbottom and Koonz *(11)* determined the relative concentration of oxyhemoglobin and methemoglobin from extracts of the surface tissue for steaks stored at 10° F. and −30° F. They found greater oxidation of the pigment to methemoglobin in the tissue at 10° F. than at −30° F.

The packaging of frozen retail meat cuts has created problems that have proven difficult to solve. They are concerned with storage conditions (which include temperature, air movement, humidity), packaging materials and methods (which include visibility, neatness of cut and tightness of wrap), and display under light. A major factor affecting the attractiveness of packaged frozen retail meat is the color of the exposed lean.

Discoloration caused by exposure to light becomes a particularly serious problem because of modern merchandising methods that require exposure of retail cuts in lighted display cases. According to Nauman *(8)*, the stability of color of frozen beef vacuum packed in flexible transparent film under 20–50 foot-candles of illumination was related to length of dark storage, foot-candle hours of illumination and temperature. Fresh meats, on the other hand, appear to be relatively unaffected under normal display conditions of light *(6, 9, 14)*.

EXPERIMENTAL PROCEDURE

The *Longissimus dorsi* muscle from U. S. Good and Choice grade beef ribs was used throughout this study. Boneless rib steaks approximately one inch thick were cut from the wholesale rib cut. All steaks were allowed to "bloom" for 30 minutes and then a 3 mm. slice was removed for spectrophotometric estimation of metmyoglobin. The cut surface was again allowed to "bloom" for color development. Steaks were then placed in a −20° F. freezer to harden for approximately one hour to facilitate packaging.

After removal from the freezer, steaks were placed in Cry-O-Vac plastic bags. Bags were vacuumized, closed with a clip, dipped into boiling water which reduced the size of the bag approximately one-third, thus giving the steaks a tight wrap. Steaks were returned to a −20° F. freezer for 24 hours. After freezing, measurement of surface color was made by use of Munsell spinning disks in the freezer. Steaks were then removed from the freezer and subjected to the various storage conditions of this investigation.

Storage Conditions

1. Temperature

All packaged frozen steaks used in the various studies were stored in a 0° F. self-service frozen food case or in a circulating air 0° F. walk-in freezer except for those used to study the effect of repeated freezing and thawing on metmyoglobin formation, which were stored in a −20° F. walk-in freezer.

2. Effect of Light

Steaks stored in the self-service case were kept under fluorescent lamps delivering 56 foot-candles of illumination. Various colored filters were used to ascertain the attribute of light that was responsible for color degradation. Steaks stored in the 0° F. walk-in freezer were kept under fluorescent and incandescent lamps delivering 56 foot-candles of illumination, except for one trial where the steaks were kept under various colored fluorescent lamps delivering 20 foot-candles of illumination.

Color Measurement

Surface color was measured on the film covered surface at storage temperature by the use of Munsell spinning disks, as described by Butler *(3)*. The same standard *(3)* was used for plotting color changes during storage. Estimation of the percent metmyoglobin was according to the same procedure *(5)* except that the pigment was converted to the CN derivative by adding a drop of 2% solution potassium ferricyanide and a drop of 0.5% potassium cyanide to each cubit after readings were obtained. Since extracted myoglobin is somewhat unstable, and the percent metmyoglobin may increase with storage *(7)*, the extraction procedure was standardized so that optical density

[a] Data from a thesis submitted by W. E. Townsend in partial fulfillment of the requirements for the degree of Doctor of Philosophy.

[b] Journal Article No. 2264 Michigan Agricultural Experiment Station. Supported in part by Title II, Research and Marketing Funds.

[c] Presented at the Eighteenth Annual Meeting of the Institute of Food Technologists, Chicago, Ill., May 27, 1958.

[d] Present address: Research Laboratories, Swift & Company, Chicago 9, Illinois.

readings were taken within approximately one hour from the time of pigment extraction.

RESULTS AND DISCUSSION

1. Temperature

Temperature fluctuations within the self-service case varied from −4.0° F. to +5.0° F. depending on the stage of the cycling of the cooling compressor. The temperature varied 9 degrees from one side to the other side of the case, with a maximum fluctuation of 22 degrees during coil defrosting (twice daily). Temperature measurements made by a 12-point recording potentiometer showed variation in temperature of steaks stored at various levels in the self-service case. Results showed that there was little difference in the percent metmyoglobin in steaks stored at various levels in the self-service case except for the top level where steaks were exposed to light and higher temperatures. Surface color of the steaks was relatively good where they were not exposed to light, but steaks on the top level became discolored in about 2–3 days.

2. Effect of pre-freezing treatment

Figure 1 shows the color changes that took place in meat wrapped in an oxygen impermeable wrapper and stored at 36° F. prior to freezing. After "blooming," the steaks had the desirable red color characteristic of oxymyoglobin. The wrapped steaks showed measurable discoloration after one hour, and after 7 hours' storage the color was comparable to that of freshly cut beef. After 9 hours' storage, the wrapped steaks were darker than when first cut. The unwrapped steak (control) discolored at approximately the same rate but not to the same degree as the packaged steaks.

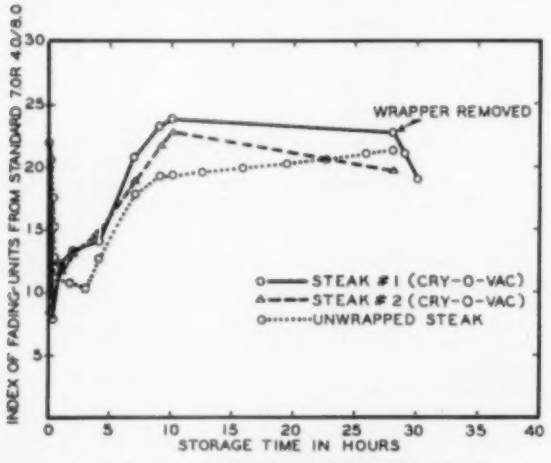

Figure 1. Color of packaged steaks as affected by length of storage at 36° F. before freezing.

Figure 1 shows clearly the change of reduced myoglobin to the red color of oxymyoglobin and then the change to the color of reduced myoglobin in an oxygen impermeable wrapping material. After 28 hours, the wrapper of one steak was removed, and it was found that the steak brightened on exposure to air.

3. Effect of freezing and thawing

Mangel *(7)* found that when samples were allowed to thaw from one to five times the methemoglobin formation did not increase with repeated thawing, but mentioned that all samples thawed more than once showed surface darkening. Figure 2 shows an alternate increase and decrease of percent metmyoglobin formation with alternate thawing (24 hr. 36° F.) and freezing (24 hr. −20° F.) cycles. The pattern of metmyoglobin formation was similar in the Cry-O-Vac packaged steaks to that of the non-fold side of the aluminum foil packaged steaks. The alternate increase and decrease in metmyoglobin values obtained between the 2nd and 7th cycles may have been due to the freezing and thawing treatment in the absence of air. In comparison, the metmyoglobin formation was progressive in the fold side of the aluminum foil packaged steaks in which there may have been some entrapped air.

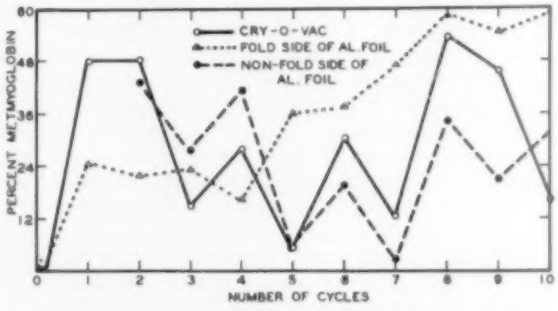

Figure 2. Effect of repeated freezing and thawing on metmyoglobin formation in steaks packaged in Cry-O-Vac and aluminum foil.

4. Effect of light

Results of this phase of the study showed that fluorescent lighting caused color degradation of packaged frozen meat when displayed in a self-service frozen food case. Figure 3 shows the absorption spectra curves for extracts from frozen steaks stored in darkness and under 56 foot-candles of fluorescent illumination for one day and for 35 days. Steaks stored in darkness and under light for one day follow about the same absorption curve. However, after 35 days storage, the presence of metmyoglobin can readily be distinguished as affected by darkness and light.

Figure 4 shows the effect of the same level of illumination (56 foot-candles) on degradation of color in prepackaged frozen meat, displayed at fluctuating and constant temperatures. Steaks stored under fluorescent light at 0° F. showed less discoloration and metmyoglobin formation than samples stored in darkness at the same temperature in the self-service case in which there was considerable temperature fluctuation. Steaks stored in the self-service case under light showed the greatest formation of metmyoglobin.

Figure 5 shows absorption spectra for extracts from packaged frozen steaks stored under various colored filters at the same level of illumination. Steaks stored

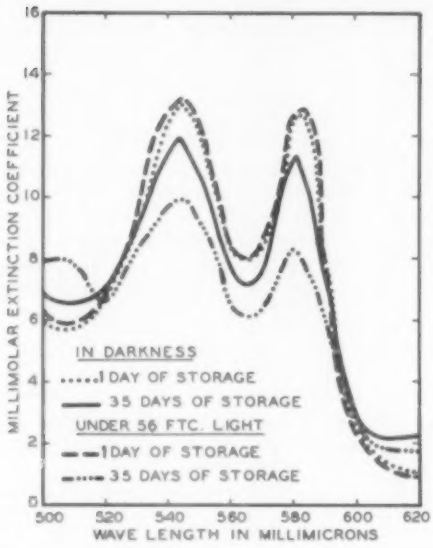

Figure 3. Absorption spectra curves for extracts from packaged frozen steaks stored in darkness and under 56 foot-candles of fluorescent illumination in 0° F. self-service case.

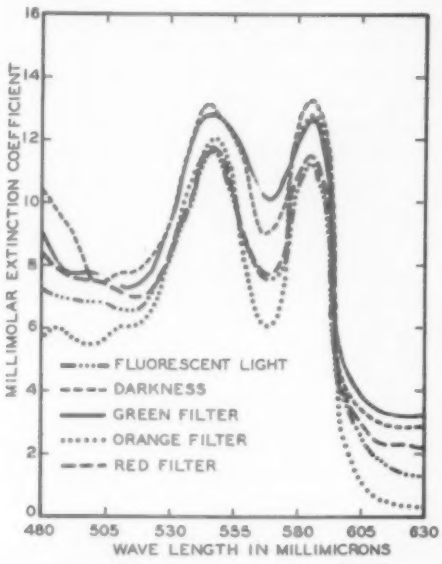

Figure 5. Absorption spectra curves for extracts from packaged frozen steaks held under various glass filters at 2–3 foot-candles illumination.

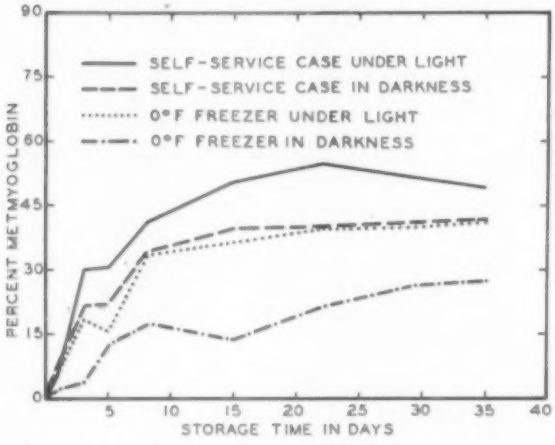

Figure 4. Metmyoglobin formation in packaged frozen steaks stored in darkness and under 56 foot-candles of illumination in 0° F. freezer and in 0° F. self-service case.

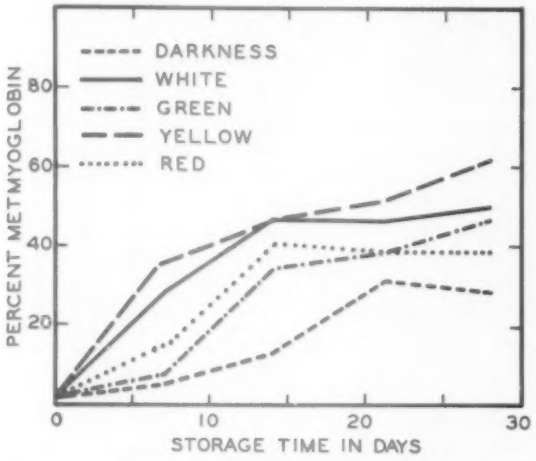

Figure 6. Metmyoglobin formation in packaged frozen steaks stored in darkness and under 20 foot-candles illumination emitted by various colored fluorescent lamps.

under no filter and under the orange and red filters showed the largest amount of metmyoglobin formation. Steaks stored under the green filter and in darkness showed the least amount of metmyoglobin formation.

Figure 6 shows clearly the effect of various colored fluorescent lamps which emit certain wave lengths of light on the degradation of color of packaged frozen meat. All steaks were displayed under 20 foot-candles of illumination. Steaks stored in darkness showed relatively little change in color, whereas those stored under the yellow fluorescent lamp and white fluorescent lamp showed the greatest color change. Steaks stored under the red and green fluorescent lamps showed color changes intermediate between those steaks stored in darkness and under the white and yellow fluorescent lamps.

Results of these studies concerning the effect of light on color degradation of frozen meat seem to indicate that wave-lengths of 5800 Å with the attendant radiation and energy are absorbed by the meat pigment, myoglobin, and as a result produce a photochemical reaction changing oxymyoglobin or myoglobin to metmyoglobin. Results would seem to indicate also that it is the yellow part of the spectrum in white fluorescent lamps that are commonly used in display cases and markets which causes the degradation of color in packaged frozen meat. This explanation is supported by Blum *(1)* and Daniels *(4)* who described the effect of radiation on photobiological processes.

Butler *(3)* found that during the period of increasing formation of metmyoglobin, there was a high correlation between the index of fading calculated from Munsell hue, value, and chroma as determined by disk colorimetry and the percent metmyoblobin determined spectrophotometrically for determination of surface color of fresh meats. He found correlation coefficients between index of fading and percent metmyoglobin ranging from 0.830 to 0.882. In this study a correlation coefficient of 0.740 between index of fading and percent metmyoglobin was obtained on 137 samples. This indicates a high relationship between surface color measured by disk colorimetry and percent metmyoglobin determined spectrophotometrically of frozen packaged meat.

SUMMARY

Temperature variations in a self-service frozen food case affect the appearance of packaged frozen meat packaged in transparent oxygen impermeable wrapping materials. Pre-freezing conditions affect initial color degradation of packaged meat prior to freezing. Likewise, repeated freezing and thawing in an oxygen impermeable wrapper has a marked effect on frozen meat color. Samples stored under fluorescent light at 0° F. showed less discoloration and metmyoglobin formation that samples stored in darkness in a self-service case in which there was considerable temperature fluctuation. Wave-lengths of light between 560 mμ and 630 mμ (yellow and orange portion of the spectrum) seem to be responsible for color degradation of packaged frozen meat. Frozen meat stored under green and red fluorescent lighting seems to have better color stability. It would appear that the yellow portion of the spectrum emitted by white fluorescent lamps commonly used for frozen food display cases and markets is responsible for color degradation of packaged frozen meat and that the formation of metmyoglobin is the primary cause of discoloration when packaged frozen meat in a transparent wrapper is exposed to light. There is a relatively high relationship between index of fading and percent metmyoglobin.

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Feeding the Army of Tomorrow*

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(Manuscript received May 11, 1958)

THE ARMY OF TODAY is an Army in transition to the tomorrow when every major nation will have an assortment of guided missiles and of nuclear explosives of assorted energy yields. It is not clear what the Army of tomorrow will look like or how it will operate, but it is obvious that our best thinking must go into arming and supplying that Army.

The trend in feeding the Army of tomorrow will undoubtedly be toward the use of foods partially prepared in a processing plant. This will reduce the expenditure of so much Army manpower in the kitchen. Moreover, it will be in keeping with the general goal of getting maximum defense for the defense dollar. The trend is helped along by the more accurate cost accounting of the defense effort in recent years. Many indirect costs which were previously buried and which by their omission swung many decisions in favor of supply items and procedures of higher over-all cost are now included.

The movement toward factory-prepared foods, however, is of interest to the food technologist only because it gives a military outlet to the products he has already developed for sale to the civilian market to satisfy its demand for packaged domestic service. The research and development challenges arise within those few years in each generation when national survival is called into question by armed conflict.

Recent history has shown us that wars can be fought between major powers without committing their full resources. If our military preparations include only those for all-out nuclear war, we risk being nibbled to death by minor involvements which do not justify precipitating international destruction. In preparing for major war, therefore, we must maintain our capacity for limited engagements. These are most likely to occur in remote, primitive areas where distribution facilities are poor and refrigeration is either unavailable or naturally plentiful and challenging rather than helpful.

FEEDING IN REMOTE AREAS

The first combat feeding situation to look at then is the organized unit messes with trained cooks and field kitchens in areas far from home and poorly equipped for food storage and distribution. Various attempts have been made to solve this problem ever since World War I. Our present supply system provides for this purpose Operational Ration B, a 15-day menu cycle of non-perishable foods that can be shipped to any part of the world without refrigeration and without spoilage. These foods meet the nutritional requirements set forth by the Surgeon General. What more could anyone ask?

Some limitations. The meats, fruits, and vegetables in the B Ration are mostly canned. Of these, the canned fruits present no serious problems, at least until the interaction of the fruit acids and the metallic containers give off-flavors or corrode through the can. The canned vegetables are somewhat less pleasing and less close to their fresh counterparts in flavor and largely for these reasons tend eventually to become tiresome. The soldier of today, conditioned by our modern food distribution system, begins to yearn for a fresh, crisp salad after a few months on only cooked vegetables. The problem with meats, however,

The B Ration . . . its limitations must be removed.

is the most serious of the lot. After the first month on only canned meats, many soldiers begin to weary of the ration to the point of altering their food intake patterns and thereby risking malnutrition. Furthermore, all the flavor defects noted become markedly worse on long storage, particularly at high temperatures. A 15-day menu rotation is also hard to maintain. The ration as a whole has over 100 components that must reach the using unit in the right balance on the right day. Strict adherence to the prescribed menu for 30 consecutive days in some remote location is most unlikely. The labor of sorting and apportioning all these components at the issue point is also a drain on military manpower.

"TO FEED THE SOLDIER OF TOMORROW . . ."

To feed the soldier of tomorrow, there is a coordinated program to remove the limitations of the B Ration. Work on fruits and vegetables is emphasizing dehydration. Results to date show that acceptability of dehydrated fruits and vegetables can be at least as good as canned. There is a marked saving in weight and some saving in space. The storage life is at least as good as canned and probably better, and there is no interaction with the container, which can be flexible with further saving in weight and space. There has been some exploration of radiation as a means of preserving fruits and vegetables, but results so far with sterilizing doses of radiation have not been encouraging.

* Presented at the Eighteenth Annual Meeting of the Institute of Food Technologists, May 26, 1958.

To preserve meats in more satisfactory fashion use has been made of dehydration, particularly freeze-drying; irradiation; and new approaches to canning. New approaches to canning have featured quick sterilization in heat exchangers, and aseptic filling and closing. It is too early to assess the results of these studies. Another approach, particularly for large cuts of meat such as steaks and chops, is to sterilize in bags made of suitable flexible films. These can be made small enough to conform fairly well to the cut of meat and thereby reduce the path of heat flow in sterilization. These studies, too, are in an early stage.

The most immediately applicable process with promise of benefits for field use for meats is dehydration. Intact cuts such as steaks and chops can be freeze-dried in raw form and grilled at the point of use to give a product moderately close to that received at home. They can be packaged in flexible films if moisture and oxygen are rigidly excluded. They tolerate unfavorable storage conditions at least as well as canned meats. Intact roasts have been dehydrated experimentally, but the process appears too cumbersome for practical use in the near future. Cured meats have so far given unsatisfactory results; although quality immediately after dehydration is good, they become rancid within a few weeks in spite of all precautions.

MEAL, UNCOOKED, 25-MAN

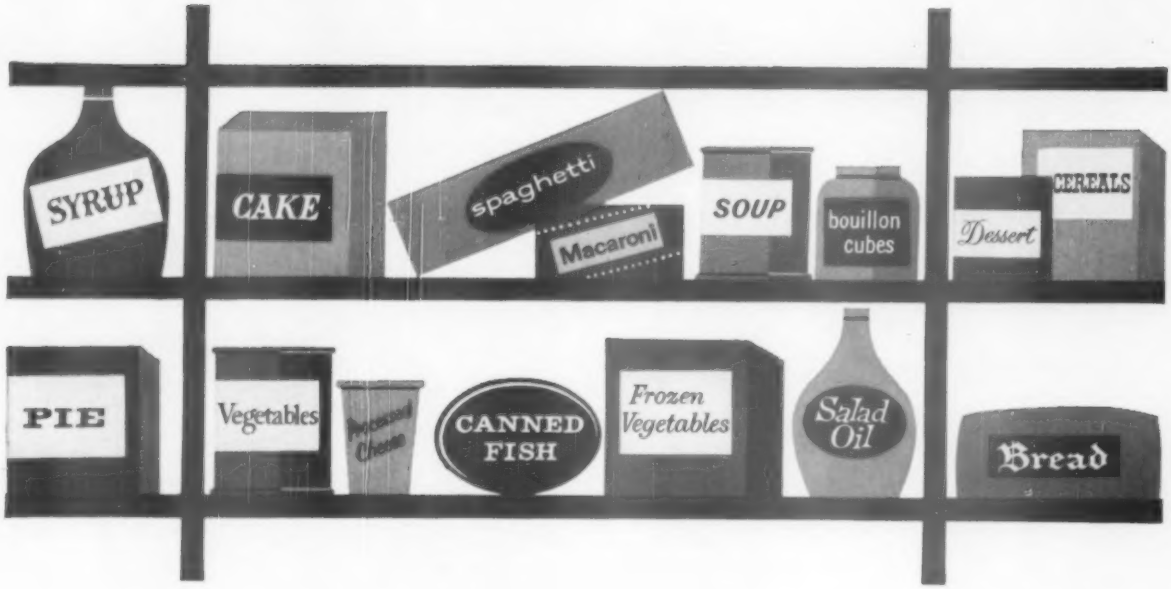
Such progress as is being achieved along the lines indicated is being made available to the soldier of tomorrow in the form of a ration presently called the Unitized Uncooked Meal (Table 1). The word "unitized" reflects the fact that all the food necessary to cook a meal for some unit module of men is contained in one shipping case. Tentatively, the size of the module is 25 men because this makes a convenient unit for shipping and handling. Further experience may alter the module size in either direction. The word "uncooked" is used not because all the food in the case is necessarily uncooked but simply to indicate to all concerned that in general this ration requires cooking—therefore, cooks and kitchens. It is called a "meal" because all rations for tomorrow's Army will be unitized by meal, all meals being nutritionally equivalent and to that extent interchangeable. This makes it possible for the field commander to use several types of ration on one day or even at the same meal, depending on the disposition of his forces and the situations they are in.

Substitution of this ration for the B Ration permits the apportionment of components of the ration to be performed on organized assembly lines with the assistance of modern industrial techniques and facilities. By removing the pressure to keep down the number of items supplied, this approach also makes possible maximum use of prepared and pre-formulated items designed for the particular menu in place of basic ingredients which must serve many purposes. Both these changes should yield a net saving in manpower for the nation as a whole and most particularly in manpower in the Theater of Operations.

TABLE 1
Unitized uncooked meal menu

Breakfast:	No. 1	No. 2	No. 3
Juice	Orange juice	Grapefruit juice	Stewed fruit
Cereal–other	Coffee cake	Oatmeal, cream	Dry cereal bars
Egg	Scrambled eggs	Pancakes w/syrup	
Meat	Bacon	Bacon	Beef and potato hash
Bread	Bread	Bread	Bread
Spread	Margarine, jam	Margarine, jam	Margarine, jam
Beverage	Coffee, cream, sugar, milk	Coffee, cream, sugar, milk	Coffee, cream, sugar, milk
Lunch:	**No. 1**	**No. 2**	**No. 3**
Soup	Lima bean soup w/crackers	Cream of onion soup w/crackers	Chicken noodle soup w/crackers
Meat	Meat sauce w/cheese	Braised beef w/tomato gravy	Breaded pork chops, cream gravy
Potatoes	Spaghetti	Mashed potatoes	Glazed sweet potatoes
Vegetable		Lima beans	Green beans
Salad	Cabbage slaw	Vegetable relish	
Bread	Bread	Bread	Biscuits
Spread	Peanut butter, jam	Margarine, jelly	Margarine, jam
Dessert	Fruit and rice pudding	Spice cake	White cake
Beverage	Coffee, cream, sugar	Coffee, cream, sugar	Coffee, cream, sugar
Dinner:	**No. 4**	**No. 5**	**No. 6**
Meat	Grilled steaks	Chicken pot pie w/cornbread top	Chili con carne w/red beans
Gravy	Brown gravy		
Potatoes	Hash brown potatoes	Diced potatoes	Rice
Vegetables	Peas	Carrots, peas	
Salad	Fried onions	Peaches	Applesauce
Bread	Bread	Bread	Bread
Spread	Margarine, jelly	Margarine, jelly	Cheese spread, jam
Dessert	Apple slice bar	Chocolate pudding	Candy
Beverage	Coffee, cream, sugar, cocoa	Coffee, cream, sugar, milk	Coffee, cream, sugar, milk

HOW TO GIVE YOUR PRODUCT THAT "SOMETHING EXTRA"



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MSG

FOR EXTRA TASTE APPEAL, add MSG to almost any processed food. MSG enhances the natural flavor of a wide variety of staple foods including canned soups, meats, and vegetables; frozen specialty foods; sausages, frankfurters, and other meat products. Having no flavor of its own, monosodium glutamate helps develop the natural flavors in processed foods in addition to boosting the savor of each ingredient. MSG can be as important as salt in a well-seasoned processed food—find out for yourself what this flavor enhancer can do.

HVP

NEED DELICATE YET RICH BACKGROUND FLAVOR to add character to your table and cooking sauces, vegetable, chicken, or beef soup; or canned stews and gravies? HVP (Hercules hydrolyzed vegetable protein) with its pleasant distinctive flavor is the product to use. HVP will strengthen natural flavors as in soups, gravies or sausages; or depending on the quantity used it could become the dominant flavor as in many table sauces or bouillon cubes . . . MSG used with HVP in the same product intensifies flavor to the maximum.

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ADDED NUTRITIONAL VALUE for cooked or dry cereals, spaghetti, specialty breads, and other items results when vital wheat gluten is included. A natural protein concentrate derived from nutritious wheat, vital wheat gluten improves the texture of baked products as well as adding the extra protein content that consumers appreciate.

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668B

There is one exception to an earlier statement that all the food for one meal is in one shipping case. The B Ration is based on supply of freshly baked bread from Quartermaster field bakeries. Conditions of warfare in the future are likely to be such that these efficient but large units may have difficulty in getting to a suitable place to operate and even more difficulty in distributing their products to their scattered consumers. To meet this situation, there is under study a new field bakery small enough and light enough to be loaded on the back of one truck of the most common type in the Army and yet capable of supplying all the bread and cake needed for one modern battle group. This bakery will use mixes exclusively. The necessary cake mixes are largely already available. An instant bread mix, which has been a technical challenge, is on the way.

Progress to date promises a successful solution of the problems of mass feeding in remote areas. This assumes, however, that future tactical conditions will permit the assembly of company-sized units for meals. The atomic battlefield is likely to make such conditions the exception rather than the rule. This situation poses the requirement of feeding small groups of men for extended periods without the use of cooks or kitchens. To meet this condition, thought has been given to distributing hot food from central kitchens to dispersed groups. With the techniques and facilities which will be available to tomorrow's field commanders, this may be feasible but it presents many problems and drawbacks if considered the main method of feeding. Obviously, the only other option is food suitable for quick preparation at the point of consumption by the consumers themselves. For this purpose there is under development a group of Quick-serve meals.

TABLE 2

Menus for meal, quick-serve, 25-man

Breakfast—25 Man: No. 1	No. 2	No. 3
Orange juice	Fruit compote	Grapefruit juice
Oatmeal	Cereal bar	Rice
Beef & potato hash	Potato sticks	Ground beef w/onion gravy
Pecan roll	Prefried bacon	Pecan roll
Fat spread	Bread	Fat spread
Coffee, cream, sugar	Coffee, cream, sugar	Coffee, cream, sugar
Dinner—25 Man: No. 1	**No. 2**	**No. 3**
Non-fat milk	Chicken rice soup	Pea soup
Chili con carne	Meat & spaghetti w/tomato sauce	Chicken and rice
Applesauce	Butterscotch pudding	Apricots
Bread	Bread	Bread
Peanut butter	Jam or jelly	Fat spread
Vanilla cream bar	Coconut bar	Chocolate fudge bar
Coffee, cream, sugar	Coffee, cream, sugar	Coffee, cream, sugar
Supper—25 Man: No. 1	**No. 2**	**No. 3**
Non-fat milk	Non-fat milk	Cocoa beverage
Chicken and gravy	Sliced beef w/gravy	Meat loaf w/tomato catsup
Mashed potatoes	Macaroni, seasoned	Macaroni & cheese
Lima beans, seasoned	Buttered cabbage	Applesauce
Bread	Bread	Bread
Fat spread	Fat spread	Fat spread
Pound cake	Chocolate fudge cake	Fruit cake
Coffee, cream, sugar	Coffee, cream, sugar	Coffee, cream, sugar

MEAL, QUICK-SERVE, 25-MAN

The Quick-serve Meals, like the Unitized Uncooked Meals, are designed in a 30-meal, 10-day cycle and unitized on a meal basis to feed a modular group of men. Here again, the tentative module is 25 men for the same reasons as before. Because it is expected that this ration will be used frequently to feed small groups, however, a module for 6 men is also being worked out. The meals will require for preparation only hot and cold water. All food, utensils, and accessories to prepare and serve a meal are otherwise in the shipping case and are expendable. Foods in this ration are mostly dehydrated cooked foods; dishes are coated paper trays; stirring and eating utensils are plastic. Preparation of one of the dishes consists typically of opening the food package, adding boiling water up to a mark, mixing, folding the top back over the mixture, and allowing to stand for 20 minutes. In some instances, better results are obtained by adding the food to the water instead of adding the water to the food. In these instances, additional bags are provided as mixing vessels.

Other elements of the QM Research and Engineering Command are also working on various aspects of the problem, for example, on the trays and utensils mentioned above. Suitable heaters to provide the boiling water will be required. For the 25-man groups, it is contemplated that a plastic liner will convert the shipping case for the meal into a heating tank. A gasoline-fired immersion heater has been designed to do the heating. For the small groups, the approach now contemplated is to pool the use of small individual gasoline stoves, newly developed for heating individual rations. Consideration has been given to expendable heating cartridges to operate without the use of stoves, and a thermite cartridge has been fabricated which will heat the water for 6 men to boiling in 2 minutes. The weight of 4 pounds for this unit, however, is considered too high a logistic price to pay for the speed. The principle, however, is still under study.

THE MEAL-TYPE COMBAT RATION

Providing hot meals to groups of men in the Combat Zone, though a challenge and quantitatively the largest requirement, leaves open the problem of the soldier in close combat. The rations described up to this point will not suitably provide for many such situations. It is to be expected in such circumstances that a man will usually eat alone or in a group smaller than 6. An individual meal is, accordingly, in order.

The first step in this direction has just been completed. Field tests by the users have resulted in standardizing an individual packaged ration which has been called loosely a "Meal-type Combat Ration" but which has now been re-designated as the Individual Combat Meal. It is basically a lineal descendant of the old C-Ration modified to be issued by meals instead of full rations, to be more acceptable when heating is impossible, and to make use of technological progress of recent years such as development of canned baked products (breads and cakes).

This ration is still too heavy for an ideal combat ration. One direction of new development in this area, therefore, is to replace cans with flexible bags, both to reduce weight and to give packages easier to carry in pockets without bulges or bruises. A second is to try to escape the limitations of canned meats. The possibilities open have been touched on earlier, but the method of most promise here is the preservation of cooked meats by irradiation. This results in a sandwich meat which requires no treatment other than unwrapping to prepare it for use. Out of these developments is expected a metamorphosis of the Individual Combat Meal which is being called at present the Individual Ready-to-Eat Meal. This will be, obviously, a sort of non-perishable box lunch for consumption cold by the individual soldier whose duties require him to be away from his organization during meals, or whose circumstances require eating a quick, cold meal.

As a concluding word—if the chemists and physicists have relegated yesterday's Army to the history books, then the food scientists from publicly supported and privately supported laboratories have speeded toward obsolescence the rations of yesterday's Army.

Effects of Light on Homogenized Whole Milk and Some Fortified Milk Products*

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(Manuscript received May 31, 1958)

A GREAT NUMBER OF food products are affected adversely by light but none perhaps so dramatically as milk. Light can affect milk principally in the following ways: by catalyzing the oxidation of ascorbic acid; by causing the destruction of riboflavin and vitamin A; and by stimulating the development of oxidized and activated flavors. Many factors influence the extent to which these changes occur. Consequently, a great deal of research has been conducted to determine the effects of such variables as type of milk, temperature, length of exposure, type of container, light source and wave length. Although the subject has been thoroughly covered in two separate review articles *(3, 9)*, it is of value to restate the existing knowledge in terms of recent developments.

Homogenized, pasteurized whole milk, the most common product studied, is affected by both fluorescent and sunlight and can be materially altered. The most striking effect is that of flavor change. Exposure of whole milk to artificial light for only a few hours will cause the development of an oxidized or papery flavor *(3)*. This defect becomes more pronounced as the exposure period is lengthened. Exposure of whole milk to sunlight results in an activated or sunlight flavor in only a few minutes time *(9)*. If the exposure period is longer than about three hours, the activated flavor dissipates. Both flavor defects may be prevented by protecting the product from light although oxidized flavors have been known to develop even when the product is protected from light.

The riboflavin content of whole milk is also affected by light *(6)*. Exposure not only destroys this vitamin but recent evidence has suggested that its destruction is coupled to the formation of compounds responsible for the flavor defects mentioned above *(7)*.

Ascorbic acid losses are also quite prevalent in whole milk subjected to light. Although whole milk is not necessarily a good source of vitamin C, due to losses in handling and processing, the vitamin C which is present is rapidly lost when the product is exposed to light. This loss of vitamin C is closely correlated to the development of the oxidized flavor described above *(4)*.

* Presented at the Eighteenth Annual Meeting of the Institute of Food Technologists, Chicago, Illinois, May 28, 1958.

Other milk products are affected by light. Vitamin and mineral fortified whole milk is susceptible to losses of riboflavin and changes in flavor. Vitamins A and D fortified skim milk is subject to vitamin A losses because the vitamin is no longer protected by fat as in whole milk. The same holds for multivitamin fortified skim milk which also loses riboflavin and other light sensitive vitamins upon exposure to light.

It has been quite clearly demonstrated that clear glass bottles afford little protection to milk against the harmful effects of light. Certain packages such as brown glass and paper containers have been shown to decrease the detrimental effects of light. The tests reported here were conducted to compare the quality of milk packaged in four different types of container under practical conditions of exposure to light.

MATERIALS AND METHODS

Four basic variables were included in the tests. The technical details in each category are:

Containers. Four quart-size containers were compared. These were clear glass, brown (amber) glass, waxed paper carton, and foil laminated waxed paper carton.

Types of milk. The majority of the tests were conducted using homogenized, pasteurized whole milk from mixed herds as the test product. Other products included for comparison were vitamin and mineral fortified whole milk, vitamins A and D fortified skim milk and a specially prepared multivitamin fortified skim milk. This last product was made by adding vitamin C, riboflavin and A and D concentrate to A and D fortified skim milk. All products were obtained immediately after manufacture from Grade A sources.

Conditions of exposure to light. After filling the products into the various containers, the test quarts were exposed to both fluorescent and sunlight conditions. Samples were placed in an open top refrigerated display case maintained at 50° F. Fluorescent lights were arranged above the case to supply an intensity of about 100 foot-candles at the product level. These conditions were designed to simulate those encountered in a modern, well-lighted supermarket. Samples were also placed in direct sunlight in the morning of a warm day in May. Tests were conducted on the samples prior to exposure and after 3 and 10 days' exposure to fluorescent light and 30 and 120 minutes' exposure to sunlight.

Analyses. Tests were conducted in duplicate for each product on the more important quality characteristics. For homogenized whole milk, riboflavin *(1)*, ascorbic acid *(8)* and flavor *(2)* were tested at the above exposure intervals. Riboflavin and flavor were tested on vitamin and mineral fortified whole milk. Vitamin A *(5)* was analyzed in vitamin A and D skim milk and multivitamin fortified skim milk. The latter product was tested for ascorbic acid while both products were analyzed for flavor defects. The temperature changes in all products subjected to sunlight were also recorded. For all factors tested, the method of analysis employed was the most exacting in current use. The results express the average of duplicate values obtained in each test.

RESULTS AND DISCUSSION

In Tables 1–4 are presented the results of tests conducted under fluorescent lighting conditions.

Losses in riboflavin content are given in Table 1. Products packaged in clear glass showed slight losses of this vitamin whereas products packaged in the other packages showed very little loss. The riboflavin in fortified skim milk seemed somewhat more susceptible to the effects of light than that of the higher fat products. Although some changes in riboflavin occurred, these losses are not of great nutritional significance when consideration is made of the time required to cause the effects noted.

Ascorbic acid changes are recorded in Table 2. Of special note are the relative losses in reduced ascorbic acid. In both products studied, the reduced ascorbic acid content of the milk in brown glass and foil laminated cartons was lowered much more slowly than that of milk in clear glass and waxed paper cartons. The losses in total ascorbic acid, while not as pronounced as losses of reduced ascorbic acid, reflect the relative vitamin C potency of the products and indicate some variation among the packages.

Vitamin A results presented in Table 3 indicate that losses of this vitamin occur only when the products are packaged in clear glass containers. All other packages afford sufficient protection to maintain the claimed added content.

TABLE 1

Riboflavin contents of three types of milk stored under fluorescent lights at 50° F. (milligrams per quart)

Package	Homogenized whole milk			Vitamin and mineral fortified whole milk			Multivitamin fortified skim milk		
	0	3	10	0	3	10	0	3	10
Clear glass	1.61	1.50	0.96	3.70	3.41	2.77	3.76	3.10	2.57
Brown glass	1.61	1.62	1.60	3.70	3.73	3.19	3.76	3.48	3.02
Waxed paper carton	1.61	1.66	1.57	3.70	3.79	3.34	3.76	3.44	2.87
Foil laminated carton	1.61	1.62	1.53	3.70	3.77	3.54	3.76	3.61	3.38

TABLE 2

Reduced, dehydro and total ascorbic acid contents of two types of milk stored under fluorescent lights at 50° F. (milligrams per quart)

Package	Homogenized whole milk									Multivitamin fortified skim milk								
	0			3			10			0			3			10		
	R	D	T	R	D	T	R	D	T	R	D	T	R	D	T	R	D	T
Clear glass	27.2	9.4	36.6	3.5	15.7	19.2	1.1	11.2	12.3	100	8	108	57.2	14.1	71.3	38.9	25.2	64.1
Brown glass	27.2	9.4	36.6	9.2	17.3	26.5	9.7	4.9	14.6	100	8	108	78.7	15.9	94.6	55.7	26.4	82.1
Waxed paper carton	27.2	9.4	36.6	8.1	17.2	25.3	2.2	11.3	13.5	100	8	108	72.5	16.4	88.9	41.1	20.4	61.5
Foil laminated carton	27.2	9.4	36.6	11.3	16.3	27.6	7.7	12.9	20.6	100	8	108	80.8	12.7	93.5	54.9	24.6	79.5

R = Reduced; D = Dehydro; T = Total ascorbic acid.

TABLE 3

Vitamin A contents of two types of milk stored under fluorescent lights at 50° F. (units per quart)

Package	Multivitamin fortified skim milk			Vitamins A and D fortified skim milk		
	0	3	10	0	3	10
Clear glass	5480	4270	2580	2570	1910	1250
Brown glass	5480	5670	5440	2570	2740	2660
Waxed paper carton	5480	5440	5190	2570	2770	2540
Foil laminated carton	5480	5670	5370	2570	2700	2720

Perhaps the most striking differences among the packages exposed to fluorescent light were noted in the flavor scores reported in Table 4. In all instances where the flavor score of the product fell to 35 or lower, the defect was a definite oxidized flavor with the whole milks and a pronounced hay-like flavor with the skim milks. The foil laminated carton was very effective in preventing these undesirable flavor changes. The brown glass and waxed paper carton only slightly retarded the development of the flavor defects. Clear glass was very ineffective with the possible exception of the multivitamin fortified skim milk. With this product, the addition of ascorbic acid undoubtedly delayed the formation of the hay-like flavor characteristic of vitamin A fortified skim milk. This is in agreement with the results of Weckel and Chicoye *(10)*. A correlation appears to exist between ascorbic acid losses and the formation of the oxidized and hay-like flavors.

Results of the tests conducted on samples exposed to direct sunlight are presented in Tables 5–9.

Riboflavin as shown in Table 5 seems to be much more sensitive to sunlight than to fluorescent light (Table 1). Substantial losses of this vitamin were obtained in the 3 products when packaged in clear glass and waxed paper cartons. Brown glass and foil laminated cartons afforded excellent protection for as long as two hours' exposure.

Ascorbic acid changes due to exposure to sunlight are recorded in Table 6. Again the brown glass and foil laminated carton are definitely superior in retarding losses of this vitamin. Reduced ascorbic acid disappears very rapidly from homogenized whole milk packaged in clear glass and waxed paper cartons. Total ascorbic acid (vitamin C) is lost more slowly (50% in two hours). As expected, the loss of both reduced and total ascorbic acid is quite rapid in the fortified skim milk when packaged in clear glass and waxed paper cartons.

Effects of sunlight on the vitamin A content of two fortified skim milk products are shown in Table 7. In both products, the vitamin A is lost rapidly when

TABLE 7

Vitamin A contents of two types of milk exposed to direct sunlight for 30 and 120 minutes (units per quart)

Package	Multivitamin fortified skim milk			Vitamins A and D fortified skim milk		
	0	30	120	0	30	120
Clear glass	4420	1190	580	2850	841	372
Brown glass	4420	4250	3900	2850	2850	2460
Waxed paper carton	4420	3980	2910	2850	2600	2090
Foil laminated carton	4420	4410	4370	2850	2910	2860

TABLE 4

Flavor scores of four types of milk stored under fluorescent lights at 50° F.

Package	Homogenized whole milk			Vitamin and mineral fortified whole milk			Vitamins A and D fortified skim milk			Multivitamin fortified skim milk		
	0	3	10	0	3	10	0	3	10	0	3	10
Clear glass	39	33	33	38.5	33	33	38.5	33	33	38.5	37	33
Brown glass	39	34.5	34	38.5	37	34	38.5	34	33	38.5	37.5	33
Waxed paper carton	39	35	34	38.5	33	33	38.5	36	33	38.5	37	33
Foil laminated carton	39	38	38	38.5	38	38	38.5	38	37	38.5	37	37.5

TABLE 5

Riboflavin contents of three types of milk exposed to direct sunlight for 30 and 120 minutes (milligrams per quart)

Package	Homogenized whole milk			Vitamin and mineral fortified whole milk			Multivitamin fortified skim milk		
	0	30	120	0	30	120	0	30	120
Clear glass	1.45	1.11	0.59	3.37	2.80	1.43	4.40	3.02	1.00
Brown glass	1.45	1.43	1.41	3.37	3.32	3.17	4.40	4.28	4.07
Waxed paper carton	1.45	1.38	1.01	3.37	3.10	2.37	4.40	3.82	2.98
Foil laminated carton	1.45	1.44	1.35	3.37	3.30	3.28	4.40	4.41	4.45

TABLE 6

Reduced, dehydro and total ascorbic acid contents of two types of milk exposed to direct sunlight for 30 to 120 minutes (milligrams per quart)

Package	Homogenized whole milk									Multivitamin fortified skim milk								
	0			30			120			0			30			120		
	R	D	T	R	D	T	R	D	T	R	D	T	R	D	T	R	D	T
Clear glass	28.7	7.2	35.9	13.0	22.8	35.8	2.3	16.4	18.7	54.1	6.5	60.6	18.0	21.3	39.3	19.1	9.2	28.3
Brown glass	28.7	7.2	35.9	27.8	5.1	32.9	24.7	8.8	33.5	54.1	6.5	60.6	45.9	11.2	57.1	39.6	9.1	48.7
Waxed paper carton	28.7	7.2	35.9	18.0	16.7	34.7	2.3	16.4	18.7	54.1	6.5	60.6	22.5	21.0	43.5	19.1	11.9	31.0
Foil laminated carton	28.7	7.2	35.9	28.7	3.5	32.2	26.2	7.3	33.5	54.1	6.5	60.6	50.1	8.3	58.4	50.1	3.8	53.9

R = Reduced; D = Dehydro; T = Total ascorbic acid.

TABLE 8

Flavor scores of four types of milk exposed to direct sunlight for 30 and 120 minutes

Package	Homogenized whole milk			Vitamin and mineral fortified whole milk			Vitamins A and D fortified skim milk			Multivitamin fortified skim milk		
	0	30	120	0	30	120	0	30	120	0	30	120
Clear glass	39.5	34	33	39	33	33	39	34	33	38.5	34	33
Brown glass	39.5	38	35	39	35	33	39	35	33	38.5	37	35
Waxed paper carton	39.5	35	34	39	37	33	39	34	33	38.5	35	33.5
Foil laminated carton	39.5	38.5	38.5	39	38	37	39	38.5	38.5	38.5	38	38

TABLE 9

Temperatures (°F.) of the four types of milk during exposure to direct sunlight for various lengths of time in minutes

Package	Homogenized whole milk			Vitamin and mineral fortified whole milk			Vitamins A and D fortified skim milk			Multivitamin fortified skim milk		
	0	30	120	0	30	120	0	30	120	0	30	120
Clear glass	55	78	88	55	78	88	55	79	90	55	81	91
Brown glass	55	80	96	55	82	96	55	87	98	55	84	98
Waxed paper carton	55	77	86	55	76	86	55	79	88	55	77	88
Foil laminated carton	55	72	83	55	72	83	55	74	84	55	74	84

packaged in clear glass containers. The waxed paper container also appears to admit enough light to cause some vitamin A destruction. Brown glass and foil laminated containers afford excellent protection to the added vitamin A.

In Table 8 are presented the flavor scores of the 4 milk products exposed to direct sunlight. All scores of 35 or below are attributable to the activated or sunlight flavor defect in the whole milks and hay-like flavor defect in the skim milks. The foil laminated carton afforded excellent protection for the flavor of all products tested. The flavor of products packaged in clear glass, brown glass, and waxed paper cartons was materially altered. In most instances, this deterioration took place within 30 minutes. As with the effects of fluorescent lights, it appears that a correlation exists between the formation of these undesirable flavors and the destruction of ascorbic acid and vitamin A, respectively.

Of added interest are the results presented in Table 9. A bright sun, no wind, and mean air temperature of 75° F. provided ideal conditions for the samples to absorb heat. The denser whole milk samples rose in temperature more slowly than the thinner skim milks. This variation in rate of temperature rise is due in part to differences in specific heat of the 2 products. There exists within each product, however, a definite difference in rate of temperature rise among the 4 packages. The relative rates of temperature rise provide an indication of the energy absorbing or reflecting properties of the packages.

SUMMARY

Both fluorescent and sunlight have marked effects on the quality characteristics of milk and milk products. Milk stored in well-lighted store display cases can undergo losses in ascorbic acid, riboflavin and vitamin A when not packaged properly. Undesirable flavor changes will occur if milk is exposed to fluorescent lighting for 3 days or more. The foil laminated carton was the only package tested which was completely effective in preventing all undesirable changes in quality under fluorescent conditions.

If milk is allowed to stand on the doorstep, in the sun, considerable changes in quality will take place. Riboflavin, ascorbic acid and vitamin A will be greatly decreased and undesirable flavors will appear. Prevention of these defects can be achieved by packaging the susceptible product in brown glass or foil laminated cartons.

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Blending and Measurement of the Properties of Shortening*

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WEBSTER DEFINES SHORTENING AS "that which shortens pastry, cake, etc." "Shortens" is defined as "to make friable as pastry with butter, lard, etc." The definitions are not very helpful or comprehensive. Bailey *(1)* designates plastic shortenings as pure fats which are of such a consistency that they may be readily spread, mixed, or worked.

Shortenings today, in general, refer to any fat, combination of fats, with or without added emulsifiers, or in some cases, oils, which when used in foods, add to the nutritional aspects of the product, lubricate the cell structure, and tend to enclose or hold quantities of air.

Shortenings as discussed in this presentation will refer to plastic fats or specifically those which are plastic or semi-solid at normal temperature. The original plastic shortenings, butter, lard, and tallow have been used in baking and food preparation since ancient times.

Historically, shortening is an American invention and the processing of vegetable oils into plastic shortening originated with the cotton industry. As a result of this industry's development after the Civil War primarily for the purpose of producing cotton linters, shortenings were developed as an outlet for the oil. The first shortenings were blends of hard and soft fats and were termed lard compounds. They were conceived and marketed as substitutes for lard. The larger meat packers played a prominent role in developing these compounds inasmuch as they were an outlet for tallow, oleo stearine, etc.

In 1910, the catalytic hydrogenation process was developed. This initiated a new era in the shortening industry. It was now possible to produce shortenings wholly from vegetable sources with improved stability and, in some cases, improved plasticity.

Shortening manufacture developed externally to the meat packing industry. By exploiting their products to the fullest extent, the manufacturers of shortening offered meat fat producers the most aggressive type of competition. New methods of refining, deodorization, and packaging were developed to enhance the quality and appearance of the product.

In general, two types of product were produced. A portion of oil could be hardened nearly to saturation and blended with liquid oil to the desired consistency, or the entire mass could be hydrogenated to the desired consistency. Each type had certain specific advantages or properties. In the latter case, greater stability was the outstanding characteristic.

Over the year, the writers have seen many changes in the shortening industry. New vegetable oils, such as soybean oil, have been utilized. Lard and tallow are no longer necessarily considered shortening agents per se, but in many cases are subjected to the same processing techniques as are the vegetable oils. Today it is possible to produce a shortening to desired specifications and performance from a wide variety of products. Newer techniques in deodorization, chilling, bleaching, blending, modification, stabilization, and laboratory control have made this possible.

Economics greatly dictates the type of edible fats and oils for domestic use in this country. At the present time, cottonseed and soybean oils, tallow, and lard are the base fats mainly used in plastic shortening. Shortening manufacture is essentially the technology of processing, blending, or modification of these fats to specified chemical and physical constants.

Many chemical and physical tests *(3)* have been developed over the years by the shortening technologists to control quality at the various stages of processing, as well to indicate and control the quality of the finished products. Some have been standardized and are official or tentative methods of the American Oil Chemists' Society. Some of the more common will be briefly discussed:

SOME COMMON LABORATORY TESTS

Free fatty acid. The free fatty acid determination essentially measures the free or uncombined fatty acid. With modern deodorization techniques, it will usually run under 0.05%. Fatty acids are much more readily removed than are the odoriferous materials. The free fatty acid content is an index of the smoke point of a shortening as well as indicative of the flavor and flavor stability. Fatty acids, in general, are more susceptible to oxidation than are fats.

Color. The color of a shortening is of little importance functionally. Its value is aesthetic in that a white product seems to be more acceptable. Within reasonable limits, the color of the shortening is not reflected in the baked products. An off-color may indicate improper processing or, in some instances, a poor quality raw material.

Iodine value. The iodine value indicates the degree of saturation of a fat and, in specific cases, will indicate the hardness or softness. On finished shortenings, it is relatively meaningless by itself. Essentially, it is of value to the processor rather than to the consumer.

Congealing point, Wiley melting point, and capillary melting point. These tests are, in general (with limitation), related to the hardness of the fat. Individually they have little meaning with respect to a finished shortening, except to the manufacturer who can relate them to his formulation and processing practices. Some consider the spread between any two of them a measure of the plastic range or temperature range over which the shortening remains in a plastic or workable state.

Unless the type of base fat used and the method of processing is known, these values are of little help in describing the attributes of a shortening. For example, a straight hydrogenated vegetable oil shortening may have a congealing point of 33° C. and be much harder at 70° F. than a meat fat shortening with a congealing point of 41° C. Similar analogies

* Presented at the Eighteenth Annual Meeting of the Institute of Food Technologists, Chicago, May 26, 1958.

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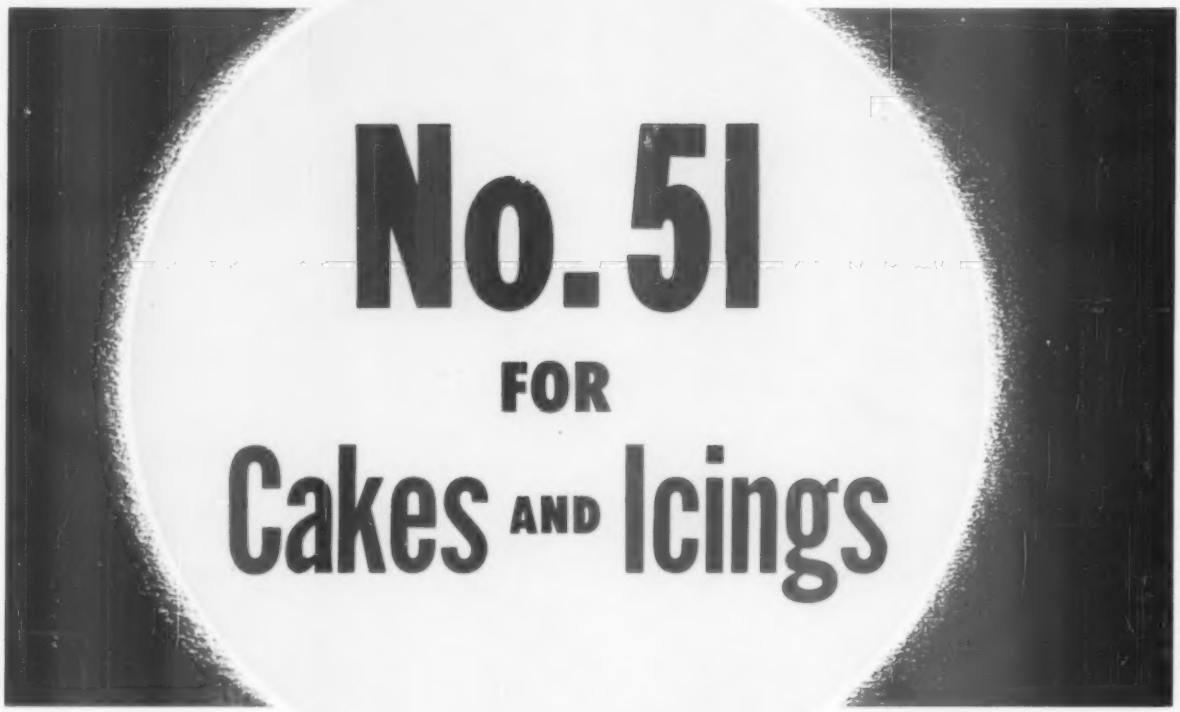

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may be made with the melting points. If the base formulation is known, then these values may have meaning in predicting the attributes of a fat.

Stability. Many stability methods are in common use but the only one listed as a tentative method by the American Oil Chemists' Society is the Active Oxygen Stability test. All tend to measure the resistance of shortening to oxidation. The A.O.M. method essentially consists of bubbling purified air at a prescribed rate through a portion of the fat, held at the temperature of boiling water until an arbitrary concentration of hydroperoxides are formed by oxidation. In a broad sense, it will indicate the shelf life of the product as far as rancidity is concerned. It will not predict the development of off flavors inherent in some base stocks or predict flavor stability.

Actual aging tests either on the fat per se or the baked or fried food at a prescribed temperature (usually 60° C.) are more indicative of shelf life.

Plasticity. The plasticity of a fat is usually measured by some form of a penetrometer. The A.S.T.M. grease cone is the one in most common use. It only measures the intial hardness or softness of a fat. This value is some indication of quality or uniformity. However, fats are thixotropic and become softer and softer when worked. This factor can be quite important in a blending operation.

A NEWER TECHNIQUE

Dilatometric solids. The newer technique of dilatometry indicates the solid fat content of a fat as differentiated from the liquid. The solid portion, of course, contributes to the body. The technique is based on the difference in the density of liquid portion as compared to that of the solid portion. This is an extremely useful tool for research purposes as well as for the control of formulation. For practical use, the solids content of fats are additive, although there are exceptions to the rule.

Table 1 shows the solids index of some common fats and shortening:

TABLE 1

Solids index of some common fats

	Solids index at				
	I.V.	50° F.	70° F.	92° F.	104° F.
Lard	66.0	27.0	20.8	4.7	2.3
Rearranged lard	66.1	20.4	10.4	5.6	1.0
Tallow	39.5	40.4	31.3	24.4	15.8
Soybean oil	130.0	0.0	0.0	0.0	0.0
Coconut oil	10.0	54.0	26.5	0.0	0.0
Plastic hydrogenated lard	54.0	34.2	29.1	21.5	16.2
Rearranged lard shortening	.....	31.9	24.6	16.5	11.3
Vegetable shortening	72.0	31.9	23.0	13.2	8.4
Vegetable margarine oil	78.0	32.0	26.0	5.0	0.0

Table 2 shows the solid index of blends of various fats and the conformance with the principle of additive solids.

It can be seen that the theoretical solids of this blend tend to agree with actual values. Table 3 shows an additional example.

Frequently, however, a solubility effect is exerted by one component. This is especially true with liquid oil. Note Table 4.

It will be noted that the actual solids index at all temperatures is considerably lower than the theoretical.

A peculiar phenomenon results when lard is blended

TABLE 2

Solids index of a blend of fats

	Solids index at				
	I.V.	50° F.	70° F.	92° F.	104° F.
Tallow	41.3	36.7	28.8	22.8	14.1
Soybean oil	91.7	12.2	6.3	1.5	0.1
63/37 Blend	59.5	29.3	21.0	14.6	6.3
Theoretical solids index		27.6	20.5	14.9	8.9

TABLE 3

Solids index of a blend of fats

	Solids index at			
	50° F.	70° F.	92° F.	104° F.
Rearranged lard	20.4	10.4	5.6	1.0
Tallow	33.0	24.8	19.6	12.4
Tallow flakes	.....	.....	.....	.....
54% R.L.—37.5 T—8.5 TF	31.2	22.3	17.7	13.5
Theoretical solids—blend	30.8	24.2	19.4	13.2

TABLE 4

Solubility effect of liquid oil on solids index

	Solids index at			
	50° F.	70° F.	92° F.	104° F.
Soybean oil	0	0	0	0
Tallow	44.0	34.7	27.7	17.7
Tallow flakes	.....	.....	.....	.....
35 SBO/57 T, 8 TF	27.4	23.0	19.1	13.3
Theoretical solids index	33.0	27.8	23.8	18.2

with other fats, especially tallow. For example, when lard at levels of 30 to 70% is blended with tallow, disproportionate dilatometric values at 50° F. are obtained. Table 5 shows values which illustrate this:

We have no explanation to offer for this phenomenon at this time. Obviously, it is essentially the opposite of a eutectic mixture where the melting point is less than that of either component. We might postulate that it may be due to the formulation of a crystalline form of higher density.

On the basis of the dilatometric results shown in the various tables, however, it may be seen that dilatometry is a handy tool for blending fat to produce uniform basic formulations.

Loska and Jaska *(2)* discussing the rheology of fats using a modified Brabender Farinograph and an A.S.T.M. grease worker, "recognized that shortenings are subject to changes by shearing or 'working' and that the system is temperature-dependent, test equipment was designed and a method was developed which would determine the relative viscosities of a

TABLE 5

Effect of lard on solids index

	Solids index at				
	I.V.	50° F.	70° F.	92° F.	104° F.
Tallow	41.0	37.7	28.5	22.1	13.7
Lard	64.0	26.5	19.5	3.7	1.5
70T-30L	47.4	46.1	25.4	13.6	7.0
Theoretical	.....	34.4	25.9	14.8	9.9
60T-40L	50.4	45.2	25.1	13.9	7.0
Theoretical	.....	33.2	25.0	14.7	8.8
30T-70L	.....	38.0	23.3	9.0	4.4
Theoretical	.....	29.8	22.1	9.2	5.1

shortening under a single shear application; the change in viscosities of a shortening as a result of controlled repeated shearing or working; and the relationships of both of these properties as a function of temperature."

In Loska's technique *(2)* which is a matter of record, a hyperbolic decay curve is developed. Using a modification of Dempster *et al.*, Loska transformed the values for easier comparisons. Thus, we quote: "The shear stress of a given stroke multiplied by the stroke number forms the ordinate and the stroke number forms the abscissa. This transformation results in essentially straight lines which can be compared easily by utilizing the origin or first stroke resistance and the slope of the line." We have also adopted Loska's technique of expressing the slope (SL) of the line at a given temperature as the tangent of the angle formed by the curve and the abscissa drawn from a one-inch line down from the curve at the eighth stroke. The initial stroke or shear resistance is designated as SR at a given temperature.

Plastic range can be expressed as the ratio of the tangent values at any two given temperatures.

We have made some runs at 70° F. and 80° F. on various typical types of shortening. Table 6 shows these values:

The lower the tangent value (SL), the softer the product. The ideal shortening would show a tangent ratio of unity. However, in the case of the shortenings listed above, it would appear that the hydrogenated lard (frying type) had excellent plasticity characteristics. This is not the case. The high SR values and low SL values indicate a brittle product with little body. The results on the flaked lard are also interesting; the SR values show a marked drop between 70° F. and 80° F. This would indicate that the product would be considerably softer at 80° F. than at 70° F.

It is quite apparent that this technique will characterize the flow properties of shortenings. The flow properties likewise have a bearing on extrusion rates, mixing time, and other factors at given temperatures.

One criticism of Loska's technique is the use of semi-rigid containers for cutting out the samples. He used number 301 x 411 (No. 1 Tall) tin cans out to a 2½ inch depth. It is virtually impossible to cut out samples without some disturbance of the crystal structure. We would recommend rigid rings of stainless steel pipe for this purpose.

To show the effect of the method of chilling the shortening on the rheological results, we obtained some "roll-in" type shortening which had been chilled by the water crystallized method. In this case, this method of chilling is used to promote a tough plasticity to the material or resistance to softening on repeated working. Its commonest use is in Danish-type pastry where repeated rolling of the dough is practised. Rheological tests at 80° F. were made on the product as received and on identical portions plasticized through a votator. Table 7 shows these results.

TABLE 7

Effect of plasticizing on rheological values

	$SR_{80°\ F.}$	$SL_{80°\ F.}$
Roll type shortening-water crystallized	1000	6.66
Roll-in type shortening-Votated No. 1	910	2.50
Roll-in type shortening-Votated No. 2	880	2.50

Samples No. 1 and No. 2 were identical and tend to indicate the accuracy of the method. In the case of the water-crystallized product, twenty-five strokes were necessary before the SR value dropped to 1000 (the limit of the machine). Eighteen strokes were necessary before SR values of 900 equal to that of the Votated product were obtained. The high SL value of the water-crystallized product indicates extreme resistance to a viscosity decrease on working. Thus, it can be seen that two shortenings with identical basic fat components, may be radically different in their plasticity characteristics if chilled in a different manner.

The production of a uniform shortening is a complex technological operation. All of the test measurements described must be employed to define its characteristics. In the final analysis, however, performance is the decisive factor. Many tests have been designed for the final evaluation. These involved standard pound cakes, layer cakes, water absorption tests, icing densities, etc. These tests vary somewhat as used by the various manufacturers and consumers of shortening, and will not be described in detail.

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TABLE 6

Rheological values on various shortenings

Type of shortening	$SR_{70°\ F.}$	$SR_{80°\ F.}$	$SL_{70°\ F.}$	$SL_{80°\ F.}$	$\frac{SL_{70°\ F.}}{SL_{80°\ F.}}$	ASTM Penet. at 70° F.
Rearranged lard	680	620	1.80	1.66	1.04	168
Hydro lard (frying type)	810	640	1.11	1.05	1.03	172
Hydro meat fat	860	660	2.22	1.25	1.78	165
Hydro veg oil (all purpose)	660	510	2.22	1.43	1.56	168
Hydro veg oil (frying type)	950	620	2.85	1.80	1.58	152
Flaked lard	870	480	1.66	1.25	1.32	180
Cake mix type No. 1	1000+	810	3.33	2.42	1.32	126
Cake mix type No. 2	1000+	820	3.10	2.50	1.28	118

A Review of the Value of Volatile Reducing Substances for the Chemical Assessment of the Freshness of Fish and Fish Products[a]

(Manuscript received May 31, 1958)

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In previous publications from this laboratory *(2, 3, 4)* the applicability of the volatile reducing substances (VRS) procedure for the quantitative evaluation of the condition of raw and canned fish has been described. Most of the data were obtained from experimental spoilage runs. During the intervening years, extensive additional data have been accumulated from the organoleptic and chemical examinations of commercial samples of raw and processed fish submitted to this laboratory.[b] The present report summarizes and reviews the data for a rather wide variety of fish and fish products. It is intended to show the correlation between sensory judgments and the content of VRS, and to call attention to the determination of VRS as a useful, rapid, reliable, and relatively easily carried out procedure for the quantitative evaluation of the state of freshness of fish and fish products of diverse types.

MATERIALS AND METHODS

Fish samples. All the samples of raw, processed, and canned fish were submitted to the laboratory for examination and opinion as to their condition. With some of the lots, control samples were submitted at the same time for comparison purposes. They were all part of commercial batches of fish.

Methods. Procedures for the determination of VRS and for volatile nitrogen compounds have been described previously *(4)*. Press juices of the samples were obtained either by manual or mechanical pressure on the fish wrapped in several layers of gauze. The entire press juice was usually centrifuged; 5 ml. of the clear aqueous supernatant was used as the sample. Each sample was given a detailed sensory examination before the press juice was prepared for the chemical tests.

RESULTS

Raw fish. Filets of various species of flat fish, including varieties referred to by such names as Dover, Lemon, Petrale, English Sole, and California Flounder, all members of the flounder family, *Pleuronectidae*, were submitted to the laboratory in various stages of freshness. Sensory and the chemical findings for representative samples of varying degrees of preservation are given in Table 1. The VRS values followed very closely the organoleptic judgments. Even though there was a general correlation with the sensory observations, the volatile nitrogen values at times showed a marked lack of correlation with the sensory observations, in contrast to the corresponding VRS values.

A number of filets of various *Sebastodes* species of rockfish, all belonging to the *Scorpaenidae* family, were also examined sensorily and chemically, with results as in Table 2. The various *Sebastodes* members are somewhat more oily or fatty than the members of the flounder family and as they deteriorate they tend to show some rancidity. Here, too, the VRS values agreed well with the sensory findings. The volatile nitrogen values also correlated with the organoleptic judgments; but the trimethylamine values tended to increase only when definite spoilage was evident.

A number of Pacific halibut, *Hippoglossus stenolepis*, in varying stages of preservation, were examined. These were dressed fish, with head, gills and entrails removed, but with tails still on. Some halibut steaks were also submitted for examination. The results for the halibut samples are given in Table 3. Correlation between the VRS values and the sen-

TABLE 1
Filets of sole and flounder

Sensory judgment	VRS[1]	TVN[2]	TMN[3]
Fresh—passable	10.3	13.5	0.4
	11.0	8.8	2.3
	8.6	12.2	1.3
Slight greenish and pink discoloration—borderline passability	14.5	14.5	1.3
Green and red discolored—definite off odor	25.4	14.1	4.9
Strong bad odor	37.6	26.6	10.5
Strong bad odor	41.0	23.7	1.9
Strong bad odor	47.0	33.0	14.5
Strong bad odor	54.8	39.2	31.3
Strong bad odor	72.1	69.5	31.7

[1] Microequivalents reduction per 5 ml. press juice.
[2] Total volatile nitrogen, milligrams per 100 ml. press juice.
[3] Trimethylamine nitrogen, milligrams per 100 ml. press juice.

TABLE 2
Rockfish filets

Sensory judgment	VRS	TVN	TMN
Fresh	7.7	9.6	2.7
Fresh	7.8	9.3	0
Fresh	8.6	11.1	0
Still passable	12.0	6.6	0
Some rancidity—fair to questionable	15.3	15.0	2.4
Pink to red discolored—definite off odor	26.4	18.4	7.2
Strong spoilage odor	62.6	44.0	30.4
Strong spoilage odor	67.0	39.2	28.0

TABLE 3
Halibut

Sample	Sensory judgment	VRS	TVN	TMN
Dressed	Good	8.7	18.6	0
		8.6	10.1	0.5
	Fair—sl. rancid	12.3	21.0	7.1
	Questionable—dehydrated and discolored	16.1	24.6	10.4
	Not passable—def. off odor present	25.7–63.5	33.6–50.6	8.5–29.9
Steaks	Not passable—bad odor	112.0–128.0	19.7–68.5	3.9–16.4

[a] Presented at the Eighteenth Annual Meeting of the Institute of Food Technologists, May 25-29, 1958, Chicago, Illinois.

[b] As part of its function, this laboratory acts as consultant on fishery matters to the California Department of Health, Bureau of Food and Drug Inspection.

sory judgments was very good. Differences in the VRS ranges for the different degrees of freshness were quite distinct. In contrast to the VRS values, the volatile nitrogen values for the various organoleptic grades overlapped markedly and the correlation with the sensory judgments, though evident, was not very close.

Table 4 shows some data for a number of salmon. Being a fatty fish, salmon readily become rancid under adverse storage conditions. The fish submitted which were judged not to be fresh were mainly dehydrated, discolored, and rancid. This probably resulted from an extended storage period in an unglazed or incompletely glazed condition and at too high a storage temperature. The VRS values correlated with the sensory findings much better than did the volatile nitrogen values. Of the latter, the total volatile nitrogen content was a better index of the condition of the fish than the trimethylamine nitrogen content, which was practically valueless.

TABLE 4

Salmon

Sample	Sensory judgment	VRS	TVN	TMN
Dressed	Good	8.5– 9.2	13.3–15.4	0 –0.3
	Passable—slight rancidity of belly cavity	11.0–13.5	15.7–23.7	0 –1.4
	Some rancidity of exposed areas—considered borderline	18.6	7.0	1.2
	Dehydrated, discolored and rancid	23.6–29.6	17.8–25.0	0.3–2.3
Steaks	Somewhat dehydrated and sl. rancid	16.8	13.4	1.9

Some data for swordfish and white sea bass (a member of the croaker family *(Sciaenidae)*) preserved to varying degrees are given in Table 5. Here again the VRS content followed very closely the sensory findings. The volatile nitrogen content increased only when definite protein spoilage was evident, but not when fat spoilage or rancidity was detectable.

TABLE 5

Swordfish and sea bass

Sample	Sensory judgment	VRS	TVN	TMN
Swordfish	Normal color and odor	3.1– 8.9	11.8–16.5	0 – 5.2
	Some rancidity noticeable	9.3–13.0	11.2–19.8	0.6– 2.6
	Sweet off odor—not passable	21.5	32.9	28.4
Sea Bass	Passable	11.1	11.5	0.4
	Dehydrated, discolored and rancid and with unpleasant odor	32.9–36.8	21.6–33.2	10.7–16.3

Data given in Table 6 were of particular interest from the standpoint of methodology. The batch of corbina (also a member of the croaker family) which was submitted to the laboratory for examination was heterogeneous. It contained fish *(a)* well glazed and normal in all respects, *(b)* fish very poorly glazed or with no glaze, which had become dehydrated and discolored and *(c)* some fish that were definitely spoiled and gave off marked unpleasant odors. In order to determine the extent of the dehydration and discoloration in the poorly glazed or unglazed samples, about a one-inch layer of the outside meat with skin was cut away from all fish for comparison with the inside layers of meat. Data for the analyses of the various corbina samples are shown in Table 6. The outer and inner layers of the well-glazed fish had a VRS content of the same order of magnitude, both layers being fairly low.

TABLE 6

Corbina

Sample	Sensory judgment	VRS	TVN	TMN
Dressed	Well glazed, normal odor			
	Outside layer	6.5– 8.5	13.4–13.8	0.2
	Inside layer	3.5– 7.0	11.1–16.4	0.2
	Poorly glazed to no glaze—dehydrated and rancid			
	Outside layer	16.8–17.6	14.7–17.6	0.2– 3.2
	Inside layer	8.0–12.9	14.5–17.6	0.2– 2.2
	Definite off-odor and discolored meat			
	Outside layer	27.6–43.5	24.8–50.4	14.4–38.2
	Inside layer	20.7–35.8	24.8–43.9	8.7–24.1

The volatile nitrogen values were also similar for this lot. The poorly glazed and unglazed specimens of corbina, which had become dehydrated, discolored, and somewhat rancid showed a definite difference in VRS content between the outer somewhat deteriorated layer of meat and the inner almost normal layer. This difference in condition between the outside and inside layers was not reflected by the volatile nitrogen values, which were the same for both of the layers, even though slightly higher than those for the first batch of samples. The samples of corbina which showed a definite protein type of spoilage organoleptically with unpleasant odors and discolored meat had a high VRS content in both outer and inner layers of meat. In this case the total volatile nitrogen and trimethylamine contents also were high.

Even though whales are mammals and not fish, data showing the applicability of the VRS method for the freshness assessment of whale meat are of interest. In Table 7 are

TABLE 7

Whale meat

Sensory judgment	VRS	TVN	TMN
Fresh-normal	4.9–11.8	1.3– 2.6	0 –0.6
Sour, unpleasant odor	36.8–44.6	20.4–75.9	0.6–1.3
Sour and rancid odors	28.0	6.6	0

shown VRS and volatile nitrogen values for fresh and spoiled whale meat samples. The VRS content of whale meat was high, compared to the fresh samples, in both the rancid sour and the protein type of spoilage with unpleasant odors. The total volatile nitrogen values were also high in the latter but not very markedly changed in the former spoilage condition. The trimethylamine content did not change in either state from the normal, which was insignificant.

Cured fish. Two different kinds of cured fish were examined. One was hard salted cod and the other was a "Scotch cure" type of imported salted herring. In both cases normal and abnormal specimens were available. Results of the examination are shown in Table 8. For the salt cod both the VRS and the volatile nitrogen values were high for the spoiled samples compared to the normal ones. For the salted herring the VRS values showed a distinct difference between the normal and spoiled specimens with unpleasant odors. In this case the oil acidity test of Charnley and Davies *(1)* was also applied but with no significant change in the acid value of the oil for both sets of samples.

Smoked fish. Two types of smoked fish, yellowtail and herring, were examined. For the yellowtail *(Seriola dorsalis*, a member of the *Carangidae* or jack family) both and raw canned smoked samples were available. The VRS and volatile nitrogen values correlated well with the raw samples. In contrast to this, the VRS values showed a greater difference between passable and spoiled canned samples than the total volatile nitrogen values, with the trimethylamine content having

TABLE 8
Cured fish

Sample	Sensory judgment	VRS	TVN	TMN
Salt cod	Characteristic odor of passable product	9.7	19.8	3.3
	Pink to red discolored—fruity and unpleasant odor—not passable	95.2	71.0	31.6
		Oil acidity[1]		
Salted herring	Characteristic odor of passable product, texture firm	46.3	10.0	
	Soft, definite unpleasant spoiled odor, not passable	63.5	9.7	

[1] Mg. KOH required to neutralize 1 ml. of expressed oil.

TABLE 9
Smoked fish

Sample	Sensory judgment	VRS	TVN	TMN
Yellowtail raw	Passable	24.9	16.2	2.3
	Discolored with honeycomb and bad odor	40.1	32.1	12.1
Canned	Passable	12.2	59.4	26.1
	Discolored with honeycomb and bad odor	40.4	72.6	23.4
Kipper snacks	Passable	16.2	51.2	22.0
Canned	H_2S and putrid odors	82.3	217.0	31.6
	Leaker, not sterile, no marked bad odor	43.5	62.3	26.5

no significance in this case as an index of the condition. For the canned kippered herring snacks (which were imported samples) the VRS content also reflected the organoleptic findings. The VRS values for the passable, sterile cans were much lower than those of the definitely or partly spoiled cans. The trimethylamine values showed the least correlation with sensory judgment; the total volatile nitrogen values paralleled to a greater extent the sensory findings.

Canned fish. Data for passable and not passable cans of abalone (*Haliotis rufescens*) in brine, jack mackerel (*Trachurus symmetricus*, a member of the *Carangidae* or jack family) in brine, and Pacific sardines (or pilchards) in tomato sauce are given in Table 10. Correlation of the VRS content

TABLE 10
Canned fish

Sample	Sensory judgment	VRS	TVN	TMN
Abalone	Seafood odor passable	13.4–38.0	20.2–23.1	2.8– 4.2
		25.7	21.7	2.8
	Strong offensive odor not passable	67.0–85.5	38.4–42.3	0.7– 2.0
		74.9	40.3	1.3
Jack mackerel in brine	Passable	2.8–15.1	60.9–74.4	25.8–31.8
	Not passable	9.4	66.2	29.1
	Pink to red discolored	57.8–71.0	57.8–70.7	15.8–19.3
		64.5	62.0	17.6
Pacific sardines in tomato sauce	Passable	8.5–36.8	.....	.....
		19.4		
	Not passable	40.5–51.3	.....	.....
		44.8		

with the organoleptically determined condition of the samples was very marked. The correlation of the volatile nitrogen values with the sensory judgments of the canned samples was much more variable. The total volatile nitrogen content was higher in the spoiled abalone samples, but not in the jack mackerel ones. The trimethylamine nitrogen values were of no significance as a spoilage indicator in either case. It was previously shown (*4*) that this also applies to canned Pacific sardines in tomato sauce.

DISCUSSION

The aim of workers in the field of quality control and freshness determination of fishery products has been to find or develop a general method which would be applicable for all kinds of fish, for all types of processed fish, and for all storage conditions. Such an ideal test would have to fulfill certain criteria before it could be accepted as the universal standard of freshness for fishery products. Among these criteria may be mentioned:

1. The test should correlate well with the organoleptic judgment.
2. The test should be applicable to all types of spoilage, including fat and protein breakdown products, so long as these lead to definite changes detectable sensorily.
3. The test should be applicable to all varieties of fish, lean and fatty, white and red meat, and to all the fish products, including cured and pickled, smoked and canned fish.
4. There should be as great a difference as possible between the content of the material, upon which the test depended, in fresh and that in spoiled samples. Furthermore, the change in content from fresh to spoiled samples should be progressive during the course of spoilage. At the beginning of spoilage or at the incipient stage of spoilage the difference in concentration of test material should be definitely detectable.
5. The best should be rapid, relatively easily carried out with as simple and readily available apparatus as possible.

Now let us examine the VRS method in the light of the above criteria. Data of Tables 1 to 10 show the close correlation with the sensory judgments. They also show that the VRS method is applicable to a wide variety of fish, lean and white meat as well as fatty and red meat; to whale meat and to invertebrates, and to such processed fish as salted, smoked and canned. The VRS method is definitely sensitive to protein spoilage. It is also applicable to the detection of fat spoilage, particularly the more marked rancidity states. The VRS content of all the fresh fish examined, except perhaps those for salted herring, raw smoked fish, and canned fish in tomato sauce, is quite low initially; it increases as the fish deteriorates to levels markedly different from the original one and the values for the stages of incipient or borderline spoilage are also quite distinct and detectable. Even for the aforementioned so-called exceptions, the spread of values between the passable or acceptable samples and those not passable is quite far apart and the respective VRS levels are distinct. Furthermore, the range of values is large enough so that the borderline or incipient spoilage stage is sufficiently distinct from the fresh range to make its detection practical. Finally, the VRS procedure is relatively simple in principle and in ease of operation. The aeration and reaction flasks can be fabricated by an experienced glassblower, if necessary, and these together with the recirculating pump constitute the apparatus. From the technical

operating point of view any person with an elementary chemistry training can carry out the determinations on a routine basis, provided that the person has been suitably inculcated with the principles of extreme cleanliness, accuracy and reliability.

Methods for spoilage determination can be classified into two broad types, those designed for laboratory use and those designed for the more practical application in the field, plant or "on the line of operation." The specifications for both these types of methods are different. The latter should be very fast to enable a quick decision to be made regarding the suitability of a load or lot of fish waiting to be processed. Such a method need be only roughly quantitative to be of practical use. The former type of method will be of use when a dispute occurs about the condition of a batch of fish, or for quality control purposes, or in any situation where a speedy answer is not the most important consideration. The VRS method was designed to serve as a quality control method of the former or laboratory type of procedure. It is not considered to be at present a plant-type of test. However, it has been adapted for this purpose in a cannery by the use of suitable colorimetric standards instead of the titrimetric procedure for the determination of the amount of permanganate reduction. In this case the color of the permanganate solution after a short aeration period was compared to suitable color standards. A judgment as to the passability or non-passability of the batch of fish being unloaded was thus obtained without having a quantitative value for the actual amount of reduction.

Taking into consideration the data presented above, which are representative of many more of a similar nature which have been accumulated during the course of years, the conclusion is obvious that the VRS procedure offers a useful and reliable means to ascertain the condition of a diversity of raw and processed fish in a relatively short time and in a relatively easy manner. Of all the laboratory methods which have been proposed to date for the determination of spoilage, the VRS method apparently comes closest to being generally applicable for the determination of the most commonly encountered types of spoilage, including bacterial breakdown and some chemical deterioration of fats. Enzymic spoilage, such as autolysis, ordinarily does not produce odoriferous or volatile products and therefore the VRS procedure is usually not applicable in this type of change. However, any change or breakdown in a fish product in which some increase in odor occurs will very likely be detectable by the sensitive alkaline potassium permanganate reagent of the VRS procedure. The VRS method was originally developed to serve as a chemical counterpart of the organoleptic judgment, particularly that of the olfactory sense. It is considered that the above representative data definitely show that the VRS method fulfills this purpose.

SUMMARY

Applicability of the VRS procedure for the determination of spoilage in a number of commercial samples of fish and fish products has been shown. Products tested included raw flat fish filets, rockfish filets, halibut, salmon, swordfish, white sea bass and corbina and whale meat, salted cod and herring, raw and canned smoked yellowtail, canned kipper snacks, and canned abalone, jack mackerel and Pacific sardines in tomato sauce. The correlation of the VRS content with the organoleptic judgments has been pointed out. The significance of the VRS method as a generally-applicable test for fish spoilage has been discussed in the light of a number of criteria and applications. It has been concluded that of all the fish spoilage tests reported to date the VRS method most closely approaches the specifications of a generally useful test for all kinds of fish and fish products and their diverse spoilage patterns under varying storage conditions.

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Effect of Variations in Curing Salts on Oxidative Changes in Radiation Sterilized Pork[a, b]

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(Manuscript received June 6, 1958)

IONIZING RADIATIONS have been shown in several recent studies to have a direct effect on curing salts (nitrites and nitrates) in aqueous solutions *(13, 14)* and in cured meats *(6)*. Such radiations may bring about a reduction of nitrate to nitrite and a simultaneous oxidation of nitrite. Since the successful curing of meat depends upon the maintenance of nitrite levels within rather narrow limits, it becomes of importance to investigate the changes in nitrite in irradiated meats.

Nitrates are not directly involved in the meat curing process, since they cannot be reduced by animal tissues *(9)*. However, they are ordinarily included in meat cures because they may be reduced slowly by bacterial action to give a continuous supply of nitrite during storage of the cured product. Thus, they are permitted in curing pickles and comminuted meats in amounts considerably greater than the maximum limits for nitrite. In cured meats sterilized by ionizing radiations, it would be expected that no transformation of nitrate to nitrite could occur during storage, since the bacteria responsible for the reduction of nitrate are destroyed. However, an immediate production of nitrite from nitrate might be expected from the radiation itself. The magnitude of this conversion has not been explored.

Nitrites may be reduced to nitric oxide by animal tissues, either by enzyme activity *(12)* or directly by protein bound sulfhydryl groups *(21)*. Nitric oxide in turn combines directly with myoglobin to form the heat stable pink pigment characteristic of cured meat. Thus, a sufficient supply of nitrite is essential during the curing process for the formation of the cured meat color and possibly also for the retention of the color during subsequent storage.

The upper limit of nitrite in meat products is legally fixed at 200 p.p.m. Too great a quantity of nitrite is highly undesirable, not only because of its toxicity but also because it produces green and gray discolorations popularly known as "nitrite burn" *(9)*. Mechanisms involved in this discoloration are incompletely understood. The nature of the discoloration suggests porphyrin ring destruction *(19)*. It is known that a lesser amount of nitrite is required to produce the discoloration with lower pH values *(3)*. The condition was not observed even with large excesses of nitrite as long as the meat gave a positive test for free sulfhydryl groups, but developed readily upon the loss of these reducing groups, and excessive nitrite itself accelerated the loss of sulfhydryl groups *(20)*.

Both nitrite and nitric oxide may be lost from meat by a variety of reactions other than that directly involved in the formation of cured meat pigment. Progressive loss of nitrite occurs in fresh pork, independent of bacterial action *(12)*. Numerous reactions are known which could account for this loss. Nitrite reacts with oxygenated heme pigments to give nitrate and methemoglobin *(7)* and with nitric oxide myoglobin below pH 6.3 to give metmyoglobin *(18)*. It may combine with methemoglobin *(19)*. Nitric oxide can be lost as a gas or reoxidized to nitrite or nitrate *(4)*. It may combine directly with ferric as well as ferrous heme pigments *(10, 11)*. As previously mentioned, ionizing radiations cause oxidation of nitrite both in the presence and absence of oxygen.

In the absence of sufficient nitrite in the cure, color development is incomplete or lacking. This in turn, may influence oxidative rancidity. It has been shown recently that the pigments of uncured meats bring about a rapid oxidation of some unsaturated fat component of tissue (probably a protein bound phospholipid) during heat treatment and subsequent storage, whereas cured meat pigments have no such effect *(15, 16)*. Loss of pigment is closely associated with fat oxidation upon subsequent storage of cured meats *(20)*.

The main objective of the present research is a quantitative determination of nitrite changes in meat as a result of irradiation and storage. The initial concentration and rates of curing salts have been varied. In view of the known interrelationships between curing salts, color and fat oxidation, pigment changes and fat oxidation have also been followed.

PROCEDURE

Treatment of meat. Fresh pork hams, purchased from local markets, were ground and mixed with curing ingredients. Sodium chloride (2%) and varying levels of nitrite and nitrate were used as indicated. Each mixture was then sealed in 307 × 113 C-enamel cans,[c] 175 grams to each can. After sealing, the cans were placed in an autoclave and heated to 70° internal temperature with streaming steam.

The cans were packed in dry ice and air-shipped to the Argonne National Laboratory gamma ray facility for radiation. Those receiving radiation were exposed to two million rad. Both irradiated samples and controls were thawed and held at room temperature during the radiation. The samples were then refrozen and returned in the same manner and analyzed initially and at storage intervals up to 6 months at

[a] This paper reports research undertaken in cooperation with the Quartermaster Food and Container Institute for the Armed Forces, and has been assigned number 879 in the series of papers approved for publication.

[b] Presented at the Eighteenth Annual Meeting of the Institute of Food Technologists, Chicago, Illinois, May 28, 1958.

[c] We are grateful to the American Can Company for donating the cans for our use.

25° C. Unirradiated cans spoiled after the first month so some of these cans were kept frozen for later analysis. The contents of each can were reground and thoroughly mixed before sampling for the analyses indicated below.

Pigment changes. Reflectance measurements were used to follow changes in heme pigments according to the procedure of Erdman and Watts *(5)*, who showed that extinction ratios at 570/650 mμ declined from an average of 2.56 at freshly exposed cured meat surfaces to 1.56 when the cured meat pigment was completely oxidized to the ferric form and to 1.33 upon complete porphyrin ring destruction. Further information on the extent of porphyrin ring destruction could be obtained from measurement of the ratio 540/500 mμ which does not change significantly upon oxidation of the heme iron but drops from 1.05 to 0.95 when the porphyrin is destroyed. It is clear from the work of Broumand and Ball *(2)*, that changes in ratio from one limiting value to another are not directly proportional to the percent of pigment change. For example, it cannot be assumed that at a ratio (570/650) of 2.06 (half way between the limiting values of 2.56 and 1.56) 50% of the cured pigment is converted to the ferric oxidation product. Nevertheless, comparison of the ratios does give useful information on the kind and relative extent of pigment changes resulting from the experimental treatments.

Fat oxidation was measured by the thiobarbituric acid (TBA) reaction as adapted to meat products by Turner *et al. (17)*. The TBA value is expressed as the optical density with a 540 filter on the Evelyn colorimeter, of the colored complex obtained from 5 g. of meat and extracted with 15 ml. of a 1:2 pyridine-isoamyl alcohol solvent according to the above method. Turner *et al.* considered the method inapplicable to cured meats. However, an investigation of the extent of direct interference of nitrite with the TBA reaction *(16)* has shown that concentrations of nitrite of 100 p.p.m. or lower do not interfere. The TBA value is decreased by approximately 20–30% when 200 p.p.m. are present at the time of analysis.

Nitrites were quantitatively determined according to the A.O.A.C. official method *(1)*.

Sulfhydryl groups were determined qualitatively as described by Erdman and Watts *(6)*.

RESULTS AND DISCUSSION

Nitrite recoveries. Nitrite recoveries after various storage periods up to six months are shown in Table 1. As shown previously *(6)* when nitrite alone was used as the curing salt, radiation caused considerable losses. Conversion of nitrate to nitrite by irradiation is apparent in all samples containing nitrate. However, only a small fraction of the total nitrate is converted to nitrite. There should be little danger of excessive amounts of nitrite appearing in irradiated cured meats even with the upper limit of nitrates permitted in cures, unless relatively large amounts of nitrite are added with the nitrate. Loss of nitrite continues during the storage period in all irradiated samples, leaving only small amounts at the end of six months. Bacterial conversion of nitrate to nitrite during storage of the unirradiated samples is apparent only in the sample containing nitrate alone. It is possible that bacteria were inhibited in the samples containing nitrite.

TABLE 1

Nitrite recovery

Treatment	Dose rad	Nitrite (p.p.m.) after various storage periods		
		2–3 days	33–35 days	188 days
100 p.p.m. NO_3^-	2 x 10^6	47.5	21	2
	none	71	15	12*
200 p.p.m. NO_3^-	2 x 10^6	80	31	2.2
	none	143	26.5	28*
400 p.p.m. NO_3^-	2 x 10^6	85	60	48
	none	271	68.5	3.3*
.25% Nitrate	2 x 10^6	75	24.5	2.4
	none	60	107	60*
.25% Nitrate + 100 p.p.m. NO_3^-	2 x 10^6	156	36	3
	none	75	28	14*
.25% Nitrate + 200 p.p.m. NO_3^-	2 x 10^6	187	47.5	5.5
	none	163	36	28*
.25% Nitrate + 400 p.p.m. NO_3^-	2 x 10^6	310	85	6.1
	none	260	24.5	58*

* Unirradiated hams held for 188 days were kept frozen.

Pigment changes. Changes in pigment may be deduced from the extinction ratios given in Tables 2 and 3. Irradiation causes an initial loss of the cured meat pigment as shown by lowered ratios at 570/650 mμ. Similar results have been reported elsewhere when cured meats have been irradiated in the presence of air *(6, 8)*. Upon subsequent storage, when moderate amounts of nitrite were present, color regeneration took place. The addition of nitrate to the cure gave no improvement in color either immediately or after storage, as compared to samples containing nitrite alone.

With excessive amounts of nitrite (over 150 p.p.m. at the first assay period) color regeneration was generally less complete. These high nitrite samples were also characterized by more rapid loss of sulfhydryl groups. At the end of the six months storage period they showed only a trace reaction to the nitroprusside

TABLE 2

Ratio of extinctions at 570/650 mμ

Treatment	Dose rad	570/650 mμ absorption ratios		
		2–3 days	33–35 days	188 days
100 p.p.m. NO_3^-	2 x 10^6	1.93	2.04	2.24
	none	2.28	2.10	2.37*
200 p.p.m. NO_3^-	2 x 10^6	1.97	2.21	2.30
	none	2.44	1.82	2.32*
400 p.p.m. NO_3^-	2 x 10^6	1.90	2.18	2.25
	none	2.38	1.97	2.07*
.25% Nitrate	2 x 10^6	1.50	1.94	2.08
	none	1.32	2.24	1.49*
.25% Nitrate + 100 p.p.m. NO_3^-	2 x 10^6	1.84	2.05	2.11
	none	2.22	2.09	2.24*
.25% Nitrate + 200 p.p.m. NO_3^-	2 x 10^6	1.91	2.13	2.07
	none	2.37	2.17	2.07*
.25% Nitrate + 400 p.p.m. NO_3^-	2 x 10^6	1.97	1.84	1.96
	none	2.38	2.20	2.32*

* Unirradiated samples held for 188 days were frozen.

TABLE 3

Ratio of extinctions at 540/500 mμ in irradiated samples

Treatment	Extinction ratios (540/500)	
	2–3 days	188 days
100 p.p.m. NO_3^-	1.06	1.03
200 p.p.m. NO_3^-	1.04	1.02
400 p.p.m. NO_3^-	1.03	1.00
.25% Nitrate	1.05	0.99
.25% Nitrate + 100 p.p.m. NO_3^-	1.04	1.00
.25% Nitrate + 200 p.p.m. NO_3^-	1.04	1.00
.25% Nitrate + 400 p.p.m. NO_3^-	1.03	0.98

test, whereas with small amounts of nitrite the nitroprusside reaction was still very strong. Extinction ratios at 540/500 mμ (Table 3) indicate least porphyrin ring destruction with 100 and 200 p.p.m. nitrite than with all other combinations of curing salts.

Fat oxidation (Table 4). Irradiated samples had generally higher TBA values than unirradiated controls at the initial analysis, but these values decreased upon storage. There is evidence that an inverse relation exists between the extinction ratios at 570/650 mμ and the TBA values. The average TBA values for each .10 increment in 570/650 mμ absorption ratios were determined from the existing data (Figure 1). TBA values remained relatively constant until the absorption ratios dropped to 1.5 when there was a decided increase in TBA values. As previously mentioned, an absorption ratio of 1.56 indicates complete oxidation of the pigment to the ferric state. Below that ratio, there is a destruction of the porphyrin ring. The sharp increase in TBA values at the 1.5 ratio is interpreted as further evidence that the ferric pigment is an active catalyst for the fat oxidation measured by TBA *(16)*. The fact that the TBA values can drop very markedly when the ferric pigment is reduced indicates the transitory nature of the TBA chromaphore.

TABLE 4

Variation of nitrite and nitrate and its effect on TBA values

Treatment	Dose rad	TBA values after various storage periods		
		2–3 days	33–35 days	188 days
100 p.p.m. nitrite	2 x 10⁶	.75	.30	.39
	none	.23	.59	.65[1]
200 p.p.m. nitrite	2 x 10⁶	.46	.27	.36
	none	.24	.61	.50[1]
400 p.p.m. nitrite	2 x 10⁶	.51	.32	.33
	none	.....[2]	.56	.48[1]
.25% nitrate	2 x 10⁶	1.12	.54	.73
	none	2.41	.38	1.68[1]
.25% nitrate and 100 p.p.m. nitrite	2 x 10⁶	0.46	.30	.38
	none	0.20	.80	.56[1]
.25% nitrate and 200 p.p.m. nitrite	2 x 10⁶	0.45	.29	.33
	none	0.21	.36	.62[1]
.25% nitrate and 400 p.p.m. nitrite	2 x 10⁶	.....[2]	.27	.34
	none	.....[2]	.31	.47[1]

[1] Unirradiated samples held for 188 days were frozen.
[2] High nitrite interferes with TBA test.

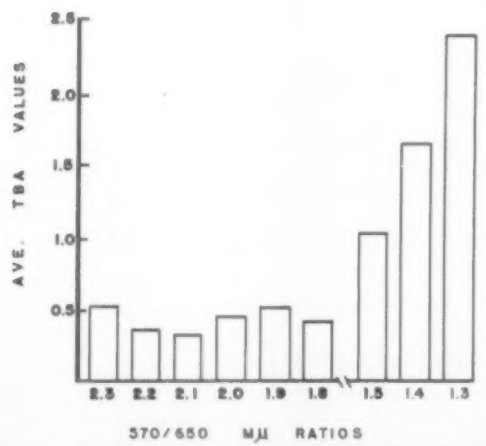

Figure 1. Relation of ferric hemochromogen to TBA values.

SUMMARY AND CONCLUSIONS

Various concentrations of nitrite and nitrate have been used in the cure of pork to be treated with gamma rays. Nitrite recoveries, pigment changes and oxidation of tissue fats have been noted after radiation and subsequent storage at room temperature. The addition of 200 p.p.m. nitrite with no nitrate appears to be optimum for formation and retention of the cured meat pigment. Irradiation converts nitrate to nitrite, but the amount of nitrite produced from this source is not sufficient to constitute a hazard. Irradiation also causes loss of nitrite.

Irradiation produces partial oxidation of the cured meat pigment which is regenerated during subsequent storage. TBA values vary with the extent of pigment oxidation. It is postulated that ferric but not ferrous hemes catalyze the oxidation of fatty components of meat tissue.

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Influence of Scald Temperatures, Chill Times, and Holding Temperatures on the Bacterial Flora and Shelf-Life of Freshly Chilled, Tray-Pack Poultry[a, b]

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(Manuscript received May 31, 1958)

A large percent of ready-to-cook poultry is marketed as freshly chilled whole eviscerated or tray-packed fryers. One of the major problems associated with the handling and marketing of unfrozen poultry is the short time keeping quality.

Considerable research in conjunction with plant sanitation has been conducted on methods of extending the shelf-life of non-frozen poultry. It was reported by Lockhead and Landerkin *(6)* and Ayers, Ogilvy and Stewart *(1)* that spoilage of poultry held at refrigerator temperatures is due to the growth of slime-forming bacteria on the exposed surface.

Dawson, Mallman, Frang and Walters *(3)* found that chlorine at 140 p.p.m. added to cooling water increased the acceptability of poultry for 5 additional days. It was reported by several workers *(2, 4, 8)* that chlortetracycline extended the shelf-life of fresh fryers. Kohler, Miller and Broquist *(5)* found in their study that chlortetracycline is more effective in extending the shelf-life of fresh poultry than several other antibiotics tested. Yacowitz *et al. (10)* reported that the use of mycostatin with aureomycin resulted in the control of bacteria, yeasts, and molds on fresh poultry.

McVicker, Dawson, Mallman, and Walters *(7)* tested the effect of chlortetracycline on the shelf-life of fresh poultry treated in a commercial processing plant. They reported that chlortetracycline was not effective in extending shelf-life of fresh poultry. They further reported that poultry meat will generally be rejected because of odor when bacterial contamination reaches a population of, or near, 1×10^6 per sq. in. No apparent relationship existed between bacterial contamination and cooked flavor of breast and thigh meat (without skin).

Ziegler and Stadelman *(11)* found that the shelf-life of poultry is extended an extra day by slack or semi-scalding (128° F.) rather than with sub-scalding (140° F.). This difference was statistically highly significant.

Processing plants use different scald water tempertures and chilling times. Holding temperatures and conditions of fresh poultry might also vary between plants and in retail stores depending on whether or not ice is used, or if the ice surrounding the poultry or trays has melted. It appears evident that further studies on the influence of these factors upon the shelf-life of fresh poultry are necessary.

MATERIALS AND METHODS

Five tests were conducted in this experiment. In the first 2 tests the fryers were processed in the poultry laboratory of the Virginia Agricultural Experiment Station and the last 3 tests in 2 commercial poultry processing plants referred to in this article as Plant A and Plant B.

In Test 1, 64 10-week old fryers were divided at random into 2 groups of 32 birds each, killed by throat slash, and allowed to bleed for one minute. One group was scalded at 128° F. (53.3° C.) for 50 secs., the other was scalded at 138° F.

[a] Presented at the Eighteenth Annual Meeting of the Institute of Food Technologists, Chicago, May 28, 1958.

[b] The helpful assistance of V. F. Holt, Department of Poultry, in conducting these tests is gratefully acknowledged.

(58.8° C.) for 30 secs. Scald water was changed between groups A small drum-type picker was used to remove the feathers.

Sixteen birds of each scald temperature group were chilled in ice slush for 4 hrs. and 16 of each group were chilled in ice slush for 16 hrs. All birds in each group were cut-up and packed in trays with blotters to absorb the moisture. Eight birds from each scald treatment and chill treatment were stored at 34° F. (±1° F.) and 8 birds from each of the 2 scald treatments and 2 chill treatments were stored at 38° F. (±1° F.). Each tray was labeled underneath to identify the treatment of the bird. Trays were overwrapped with M.S.B. 7-300 cellophane film and heat sealed. The birds were placed in 24-head wire-bound wooden crates, covered with flaked ice, and placed in the coolers. All trays were kept covered with flaked ice for the first 7 days after which time they were placed on slatted shelves in their respective coolers.

The odor of each bird was examined daily by the same 2 people starting on the 10th day of storage. The overwrap was loosened to permit examination and then folded under the trays again. Birds were discarded when off-odor became apparent. The identity of the bird was not checked until it was discarded. The bird number and storage time were obtained in order to determine the average shelf-life in number of days for each group.

Two birds each from those scalded at 128° F. and those scalded at 138° F., chilled for 4 hrs., and held in the 34° F. cooler were kept 2 extra days after rejecting from off-odor when slime development became apparent. Single skin samples 3 cm.^{2} were taken from the breast area of each bird with a sterile scalpel, placed in a sterile buffer solution, and thoroughly shaken. Inoculum dilutions were transferred to pour plates containing GTE Agar and incubated at room temperature. Total plate counts per cm.^{2} of skin were made after 48 hours. The average total count for the 2 birds of each treatment was determined.

Media and procedures employed were those described in the *Manual of Microbiological Methods (9)*.

In Test 2, 48 ten-week old fryers were processed similarly to those in Test 1, except one group of 24 fryers was scalded at 128° F. (53.3° C.) for 60 secs. and the other at 138° F. (58.8° C.) for 60 secs. Scald water was changed between groups. All carcasses were chilled in ice slush for 4 hrs. Each group was then divided at random into 2 groups of 12 fryers each. Carcasses were cut-up and tray-packed as described in Test 1. One group of 12 birds scalded at 128° F. and another group scalded at 138° F. were tray-packed and placed on slatted shelves in the 34° F. cooler. The other 2 groups of each scald temperature were placed in the 38° F. cooler. The birds were examined daily for odor after the 10th day of storage as described previously.

In Test 3, 48 ten-week old fryers were scalded at 136° F. (57.7° C.) for 45 secs. in Plant A. Twenty-four fryers were chilled in ice slush for 2 hrs. and the other 24 for 18 hrs. Birds were cut-up, tray-packed, and placed in ice for transporting to the Experiment Station Laboratory. Twelve of each group chilled for 2 hrs. and 18 hrs. were placed on slatted shelves in the 34° F. cooler. The other 12 fryers of each group were placed in the 38° F. cooler. Carcasses were examined daily for odor starting on the 7th day in storage.

In Test 4, 48 fryers were again processed in Plant A, and scalded at 136° F. Twenty-four birds were chilled for 2 hrs. and the other 24 for 12 hrs. Each group was divided into 2 groups of 12 birds each, cut-up, and tray-packed for storage as described in Test 3.

In Test 5, birds were processed, chilled, and tray-packed in Plant B which uses chlortetracycline in the chill water. Ninety-six 10-week old fryers were scalded at 128° F. for 55 secs. The carcasses were divided into two groups of 48 birds each. Twenty-four birds were chilled in ice slush for 4 hrs. and the other 24 birds for 24 hrs. without chlortetracycline in either of the chill waters. The other group of 48 fryers was also divided into 2 groups of 24 birds each. The same chill times were used; however, chlortetracycline was added to the chill water at the recommended level.

Each bird was cut-up, tray-packed and coded as before. Trays were covered with flaked ice for transporting to the Experiment Station Laboratory. Fryers were divided into 8 groups of 12 birds each. One group each which had been chilled for 4 hrs. and 24 hrs. with and without chlortetracycline in the chill water, was placed in the 34° F. cooler. The corresponding groups of these 4 treatments were placed in the 38° F. cooler. Examination for odor was checked as previously described. The observed differences in shelf-life time in days for all tests were subjected to analysis of variance.

RESULTS AND DISCUSSION

The average total bacterial count at the time slime developed in Test 1 was similar for fryers scalded at 128° F. (53.3° C.) for 50 secs. and 138° F. (58.8° C.) for 30 secs. The average count was approximately 1×10^7 per cm.^{2} of skin surface for those scalded at 128° F. and 1.6×10^7 for those scalded at 138° F. It is doubtful that this difference in bacterial numbers is important since both counts are extremely high.

Similar types of bacteria were isolated from the fryers when slime occurred. Those isolated from the skin of birds scalded at 128° F. were predominantly *Achromobacter delicatulum* and *Alcaligenes faecalis*. Those from the 138° F. scalded birds were *Pseudomonas mephitica*, *Flavobacterium devorans*, and *Alcaligenes faecalis*. These bacteria grow quite well at low temperatures and are common to soil, water, or fecal material. It is possible that other psychrophilic bacteria were overlooked since the plates were incubated at room temperature.

As shown in Table 1, shelf-life was extended by approximately 5 days by chilling in ice slush for 4 hrs. instead of 16 hrs. at both scald water temperatures. Storage at 34° F. extended the shelf-life 4-6 days more than those stored at 38° F. These differences in shelf-life for both chill time and storage temperature were significant at the 1% level probability, Table 2. It seems doubtful that the difference in bacterial counts between chill treatment groups after slime developed would account for all of the off-odor 2 days earlier in the birds chilled for 16 hrs. However,

TABLE 1

Test 1. Treatments and shelf-life in days of fryers processed in Experiment Station Laboratory

No. per treatment	Scald temp. F	Scald time, sec.	Ice slush chill, hrs.	Cooler temp., av. days of shelf life[1]	
				34° F.	38° F.
8	128°	50	4	26.00	21.13
8	128°	50	16	20.75	15.00
8	138°	30	4	26.50	19.38
8	138°	30	16	20.25	14.25

[1] Trays in flaked ice first 7 days.

TABLE 2

Analysis of variance of data, Table 1

Source of variation	d. f.	Mean square
Between treatments	7	156.88**
Scald temperature	1	6.25
Chill time	1	517.56**
Storage temperature	1	564.06**
Scald x chill	1	0.01
Scald x storage	1	6.25
Chill x storage	1	0.07
Scald x chill x storage	1	3.99
Error	56	1.63

** $P < .01$.

the type of bacterial flora which grew during the storage period might well account for the difference and would be expected to vary with processing treatments. Scald temperatures did not significantly extend the length of shelf-life of fryers chilled for the same length of time or held at the same storage temperature.

In Test 2, the same scald water temperatures were used as in Test 1. However, scald time was 60 sec. for both water temperatures and both groups were chilled in ice slush for 4 hrs. Results are shown in Table 3. The longer shelf-life of birds scalded at 128° F. for 60 sec. was significant at the 1% level of probability, Table 4. Ziegler and Stadelman *(11)* reported a difference in shelf-life of birds scalded for 40 secs. at 128° F. and 140° F. The difference between shelf-life at different storage temperatures was not significant when both groups were scalded for the same length of time. For different scald times at 128° F. and 138° F., as shown in Table 2, however, the difference in shelf-life in the two coolers was significant at the 1% level. Apparently, there is a relationship in shelf-life between the length of time birds are scalded at 128° F. and 138° F. and subsequent storage at 34° and 38° F.

It may be noted that the length of shelf-life was approximately 3 to 8 days longer in Test 1 for those chilled for 4 hrs. than for the corresponding groups in Test 2, Tables 1 and 3, respectively. This difference was perhaps due to the shorter scald time and to the storage of trays in flaked ice for the first 7 days in Test 1.

TABLE 3

Test 2. Treatments and shelf-life in days of fryers processed in the Experiment Station Laboratory

No. per treatment	Scald temp. F.	Scald time, sec.	Ice slush chill, hrs.	Cooler temp., av. days of shelf-life	
				34° F.	38° F.
12	128°	60	4	17.58	16.75
12	138°	60	4	16.00	16.08

TABLE 4

Analysis of variance of data, Table 3

Source of variation	d. f.	Mean square
Between treatments	3	6.47*
Scald temperature	1	15.19**
Storage temperature	1	1.69
Scald x storage	1	2.52
Error	47	1.73

* $P < .05$.
** $P < .01$.

For birds scalded at 136° F. in Plant A, Test 3 and 4, Tables 5 and 7, there was a highly significant difference in shelf-life between the 2 and 18 hr. chill, and the 2 and 12 hr. chill at either storage temperature as shown in Tables 6 and 8, respectively. Shelf-life was extended approximately 1 to 1½ days by the shorter chill time in both Test 3 and Test 4 and by the same number of days in the 34° F. cooler than in the 38° F. cooler. It may be noted that the 2 hr. chill period in Test 3, Table 5, resulted in approximately an extra day shelf-life at both cooler temperatures than did the group chilled for 2 hrs. in Test 4, Table 7. This difference might be due to the method of removing the feathers. Feathers were removed by a drum-type picker in Test 3 and by a more recent type of picker in Test 4, which perhaps influenced the degree of bacterial contamination on the birds. The detrimental effect of increased chill time may indicate increased bacterial contamination and activity or increased physical tissue destruction due to excessive contact with water.

TABLE 5

Test 3. Treatments and shelf-life in days of fryers processed in Plant A

No. per treatment	Scald temp. F.	Scald time, sec.	Ice slush chill, hrs.	Cooler temp., av. days of shelf-life	
				34° F.	38° F.
12	136°	45	2	13.83	12.33
12	136°	45	18	12.25	10.50

TABLE 6

Analysis of variance of data, Table 5

Source of variation	d. f.	Mean square
Between treatments	3	22.30**
Chill time	1	35.02**
Storage temperature	1	31.69**
Chill x storage	1	0.19
Error	44	0.99

** $P < .01$.

TABLE 7

Test 4. Treatments and shelf-life in days of fryers processed in Plant A

No. per treatment	Scald temp. F.	Scald time, sec.	Ice slush chill, hrs.	Cooler temp., av. days of shelf-life	
				34° F.	38° F.
12	136°	45	2	14.8	13.2
12	136°	45	12	13.0	11.9

TABLE 8

Analysis of variance of data, Table 7

Source of variation	d. f.	Mean square
Between treatments	3	8.80**
Chill time	1	11.02**
Storage temperature	1	15.19**
Chill x storage	1	0.19
Error	44	0.78

** $P < .01$.

In Test 5, Table 9, comparisons were made on the shelf-life of birds chilled for 4 hrs and 24 hrs., with and without aureomycin in the chill water. The 4 hr. chill time extended the average shelf-life approximately 1 extra day in either cooler over those chilled for 24 hrs., with or without aureomycin in the chill water. However, when the same chill time or storage temperature is compared, birds chilled in ice slush with aureomycin had a longer shelf-life than did those without aureomycin. It is interesting that the 4 hr. chill period without aureomycin gave a slightly longer average shelf-life than did the 24 hr. chill time with aureomycin. This was true of birds stored at both 34° and 38° F. Chill times, aureomycin, and storage

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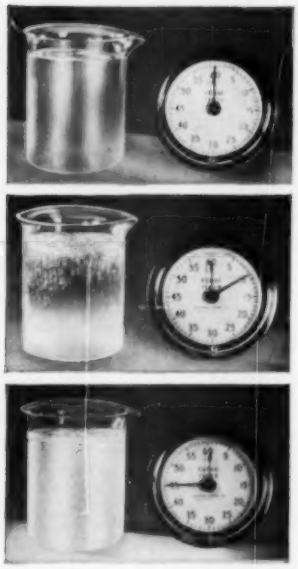

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TABLE 9

Test 5. Treatments and shelf-life of fryers processed in Plant B

No. per treatment	Scald temp. F.	Scald time, sec.	Ice slush chill, hrs.	Aureomycin chill water	Cooler temp., av. days of shelf-life	
					34° F.	38° F.
12	128°	55	4	No	12.50	11.33
12	128°	55	24	No	10.25	9.17
12	128°	55	4	Yes	13.30	12.20
12	128°	55	24	Yes	11.10	10.00

TABLE 10

Analysis of variance of data, Table 9

Source of variation	d. f.	Mean square
Between treatments	7	23.45**
Chill time	1	30.38**
Aureo. vs. no aureo.	1	16.67**
Storage temperature	1	143.80**
Storage x aureo.	1	0.00
Chill x storage	1	0.04
Chill x aureo.	1	0.00
Chill x storage x aureo.	1	2.00
Error	88	0.80

** $P < .01$.

temperatures extended the shelf-life which was significant at the 1% level of probability as shown in Table 10.

SUMMARY

Five tests were conducted in the Experiment Station Laboratory and two commercial processing plants to determine the effect of different scald temperatures, chill times, and storage temperatures on the bacterial contamination and shelf-life of tray-pack fryers. Comparisons of shelf-life were also made between fryers chilled for different length of time, with and without aureomycin.

Total bacterial counts per cm.^{2} of skin from fryers scalded at 128° F. for 50 secs. and 138° F. for 30 secs., when slime developed, were approximately 1×10^7 and 1.6×10^7, respectively. Bacteria isolated from both scald groups were similar in type in that they grow quite well at low temperatures and are common to soil, water, or fecal material.

Shelf-life as determined by odor was not significantly different between fryers scalded at 128° F. for 50 secs. and 138° F. for 30 secs. However, when the scald time was 60 secs. for each of these scald temperatures, shelf-life was significantly higher at the 1% level of probability for the 128° F. scalded fryers.

The influence of different chill times on the subsequent shelf-life was determined by comparing fryers chilled in ice slush for 4 and 16 hrs., 2 and 18 hrs., 2 and 12 hrs., and 4 and 24 hrs. In every test the average shelf-life was extended by the shorter of the two chill times. This increase was highly significant. Except in Test 2, fryers stored at 34° F. remained free of off-odors approximately 1 day longer than did those stored at 38° F. This difference in shelf-life was significant at the 1% level of probability.

Aureomycin in chill water extended the shelf-life of fryers approximately an extra day with both the 4 and 24 hr. chill periods. Fryers chilled 4 hrs. without aureomycin gave a longer shelf-life than did those chilled 24 hrs. with aureomycin in both 34° and 38° F. coolers.

The longest shelf-life observed for any combination of treatments to birds processed in Plant A was 14.8 days for fryers scalded at 136° F. for 45 sec., chilled in ice slush for 2 hrs., and held in a 34° F. cooler. In Plant B, the longest shelf-life observed was 13.30 days for fryers scalded at 128° F. for 55 secs., chilled for 4 hrs., treated with aureomycin, and held in a 34° F. cooler.

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Origin and Prevention of Undesirable Flavor Changes in Oat Products During Storage [a]

(Manuscript received March 3, 1958)

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A VERY DISAGREEABLE CHANGE occurring during the storage of oat products is the appearance of a bitter and astringent off-flavor. The inherent bitterness of the oat grain can be removed to a considerable extent by steaming.[b] Heretofore, it has been unknown how far the control of the steaming process would prevent the reappearance of the bitter flavor during storage of the finished product. The aim of this research was to find the connection between the steaming conditions and organoleptically-definable changes during storage and by means of organic-analytical tests to gain a proper insight into the embittering processes causing decay (work still to be completed).

We started with the concept that oat products grow bitter because of enzymatic processes. These processes are more or less curtailed by steaming. This working concept proved fruitful in evolving a comparatively simple method for the control of the process, leading to a more uniform quality of the product.

The peroxidase activity was judged to be an objective criterion for the inhibiting action of the steaming process on account of the high temperature stability of peroxidase. Moreover, the determination of this enzyme in the oat grain provides a comparatively simple test suitable for serial tests. British scientists have shown that lipase is also acceptable as a test enzyme *(2)*. A lipase activity check was also included, but, for reasons to be stated, only as an additional test, notwithstanding the obvious importance of lipolytic changes.

PROCEDURES

Peroxidase test *(8)*.

1. *Quantitative Determination*

1.1 *Working principle:* The method of determining peroxidase is based on the relationship between the reaction velocity and the relative quantities of enzyme, hydrogen peroxide, *o*-tolidine and ascorbic acid at the point of optimal reaction (pH 5.0).

1.2 *Test procedure:* Add to 4 cc. of ascorbic acid 10 cc. of buffer solution, 5 cc. of H_2O_2 (both heated to 25° C.), 1.0 cc. of *o*-tolidine and 1.0 cc. of enzyme solution, note the time and dilute with bi-distilled water of 25° C. to 50 cc. After 15 minutes (in case of low peroxidase activity after 30 minutes or at the utmost after 45 minutes) of standing in a controlled water bath at 25° C. the reaction is interrupted and 10 or 20 cc. of the test batch are pipetted into a flask containing 2.5 cc. or 5.0 cc., respectively, of 2N–H_2SO_4 and titrating the residual ascorbic acid with a N/250 iodine solution in the presence of 8 to 10 drops of a 1% starch solution as indicator (x cc.). To run a blank (a cc.), acidify the batch with 12 cc. 2N–H_2SO_4 prior to adding the enzymes. Choose an enzyme quantity so that 20% of ascorbic acid is oxidized and the determination does not take more than 45 minutes. The constant, k, of monomolecular reaction may then be computed from the formula:

$$k = \frac{1}{t} \log \frac{a}{a - x}$$

Peroxidase Unit (PU_{ox}) is defined as 1000 k. It represents a measure for the peroxidase activity within the test procedure.

Peroxidase Value (PV_{ox}) is defined as the number of PU_{ox} in 1 g. of the test substance.

1.3 *Computation of Peroxidase Values* (PV_{ox}) *from the* PU_{ox} *found by the test*

When 20 cc. of test substance are used and all the requirements of the test procedure are observed, the PV_{ox} is calculated as follows:

$$PV_{ox} = \frac{PU_{ox} \text{ of the test batch} \times 250}{\text{Test substance (g.) in 100 cc. } H_2O \times \text{cc. of enzyme solution (sedimentation) contained in 50 cc. batch}}$$

2. *Qualitative Test*

2.1 *Working Principle*

The qualitative test for peroxidase is made according to a quick test procedure developed in this Institute. The peroxidase activity (PV_{ox}) is estimated by comparing the time of appearance of the peroxidase reaction (appearance of blue color) in plant or animal tissues.

2.2 *Test Procedure*

Dilute 10 cc. of buffer solution, 5 cc. of H_2O_2 and 1 cc. of *o*-tolidine with bi-distilled H_2O to 50 cc. Add to 10 cc. of this solution 200 mg. of plant or animal tissues and take the time. In case none or only a faint blue coloring appears in 10 minutes' time, the test for peroxidase is negative or practically so.

TECHNOLOGICAL EXPERIMENTS AIMED AT INHIBITING THE APPEARANCE OF BITTER FLAVORS

The effect of the steaming process on the inhibition of the bitter principle is the first question.

To answer this, a special steaming vessel had to be built *(3)* which permits heat treatment at a constant moisture content *(3)* with heating-up and cooling-off times negligible compared to the constant-temperature period. It consists of 2 concentric cylinders whose distance has been so chosen that only 2 groats can lie along a radial line. Bottom and lid can be added to the cylinder cavity by quick fastening. The vessel is immersed in the liquid, serving as a thermostat. Owing to the high heat conductivity of the device, the desired steaming temperature is obtained within 3 minutes. The correct moisture content is maintained by bringing the moisture content of the grains to a high level at 0° C. and then reducing the moisture content to the desired value in a vacuum drying oven held at 35° to 40° C.

The uncomplicated apparatus described allows independent variations of temperature, moisture content and heating time over a wide range so that all factors may be separately studied.

[a] This paper, a summary of the various papers published in German periodicals on the inhibition of the bitter and astringent flavor of oat products, covers work done at the Institute of Food Technology and Packaging, Munich, West Germany.

[b] (Heat treatment at a high and nearly constant moisture content.)

After steaming, the groats were ground down and the throughs of mesh 35 (American standard sieves) used.

The organoleptic test was based on the aroma and flavor of the oatmeal, since cooking destroys characteristic differences.

RESULTS AND DISCUSSION

Some preliminary tests gave the following results: By short steaming the usual more or less bitter and astringent taste of the untreated oats vanishes. The steaming must be prolonged for the more bitter varieties of the raw oat grains. Since the steaming was done in a closed vessel, water vapor distillation is not responsible for the reduction of the bitter flavor.

The bitter flavor of the untreated oats differed noticeably for the different varieties and growths and was in general more marked than the astringent component. Steam treatment at 95° C. and 15% moisture content led to the loss of the disagreeable flavor components after the following periods (Table 1).

TABLE 1

Flavor score[1] of different varieties of raw oats after various steaming times[2]

Variety Nr.	Initial flavor score		Flavor score after steaming		Steaming time	Final PV_{asc}
	Bitter	Astringent	Bitter	Astringent		
					(minutes)	
a	2	2	<0.5	0	60	2
b	1.5	0.5	0.5	0	19	2
c	1	0.5	0	0	5	6–7
d	3	3	0	0–0.5	19	2.1
e	3	3	0.5	0–0.5	25	1.5
f	1	1	0	0	5	5
g	0.5	0	0	0	5	15
h	2.5	2.5	0	0	27	2

[1] Flavor scores: 0 = fully satisfactory; 1 = still salable; 2 = bitter or astringent; 3 = considerably bitter or astringent.
[2] Steaming at 95° C. and 15% moisture.

Table 1 shows that in all cases of an initial considerable bitter or astringent flavor, a final PV_{asc} of about 2 was equivalent to an inhibition of the bitter flavor. For untreated oat varieties of only slight bitterness, such a low final PV_{asc} would not have been required. But in order to be on the safe side and, since an excess of steaming is less injurious than too short a steaming, a PV_{asc} standard of 2 was aimed for in all successive experiments.

Other tests, not reported in this paper, showed that dehulled oats are rather sensitive to storage at the higher relative humidities. It was also shown that the untreated hulls are comparatively bitter and do not lose their bitter taste by steam treatment, as is the case for the groat.

The kinetics of inhibition can best be represented by the interpolation formula $PV_{asc} \cdot t^n = \text{const.}$ where t = time of steam treatment. Hence, the rate of peroxidase inhibition:

$$\frac{d\,(PV_{asc})}{dt} = n \cdot (\text{initial } PV_{asc}) \cdot t^{n-1}$$

which, for the coefficient $n = 1$, turns into

$$\frac{d\,(PV_{asc})}{dt} = (\text{initial } PV_{asc}).$$

With the different oat varieties, n lies between 1.0 and 2.25. The Q_{10} at 8% moisture content within the temperature range of 125 to 115° C. amounts to about 2, between 115 and 105° C. to about 4.4, between 105 and 95° C. to about 5 and between 95 and 85° C. to at least 60. At 14.5% moisture content Q_{10} between 105 and 95° C. is about 10, within the range of 95 to 85° C. about 360.

The lipase activity was determined according to Purr *(9)*. After 6 minutes of heat treatment at 15% moisture content and 95° C. the lipase activity was completely inhibited.

STEAMING PERIOD, FIXED MOISTURE CONTENT, FIXED STEAMING TEMPERATURE

The influence of steaming period at a fixed moisture content and for a fixed steaming temperature on the keeping quality of oat products stored at a fixed equilibrium moisture was studied *(5)*.

Untreated oats easily turn sour during storage, even at a moisture content as low as 8.5%, however, not at 5%. At 5% and also at 8.5% moisture content, they acquire a sweetish flavor and a rancid smell. At 13% oats may acquire a "yeasty" flavor, but they always turn sour.

The question was whether the maintenance of a $PV_{asc} = 2$ would prevent or delay the appearance of these off-flavors. Storage tests with several oat varieties at moisture contents of 12 to 13% showed that a final $PV_{asc} = 2$ is not a sure means of inhibiting the astringent flavor of oatmeal during storage. But all changes during storage tend to decrease with increasing steaming time. The decisive factor is nevertheless the storage time. At a PV_{asc} of 2, two months' storage seems, in general, to be admissible, but not so in the case of 4 months' storage at 30° C. It is worthy of note that the moisture content at a relative humidity of 70% depends somewhat on the variety of the oats, but usually lies between 12.5 and 13.9%. The lowest equilibrium moisture content is found in varieties which have ripened in a dry and hot climate.

THE PROBLEM OF EQUIVALENT STEAMING CONDITIONS *(3)*

In a large number of tests with the same oat variety, the moisture content, steaming time and temperature were systematically varied. Some results for a $PV_{asc} = 2$ are shown in Figure 1. Rather high temperatures would be needed to inhibit the peroxidase in groats of low moisture content. The oat products brought to a $PV_{asc} = 2$ in different ways show, as was expected, not the same flavor. With increasing temperatures and thus decreasing moisture content (and identical steaming periods) the nut-like flavor turns into a peanut-like flavor—and for still higher temperatures a slightly malty flavor and a raw roast aroma. At low steaming temperatures and consequently high moisture content, the flavor turns from *insipid* to *chalky or starchy*. The shelf life of the same oat variety *(5)* which had been steam-treated in 3

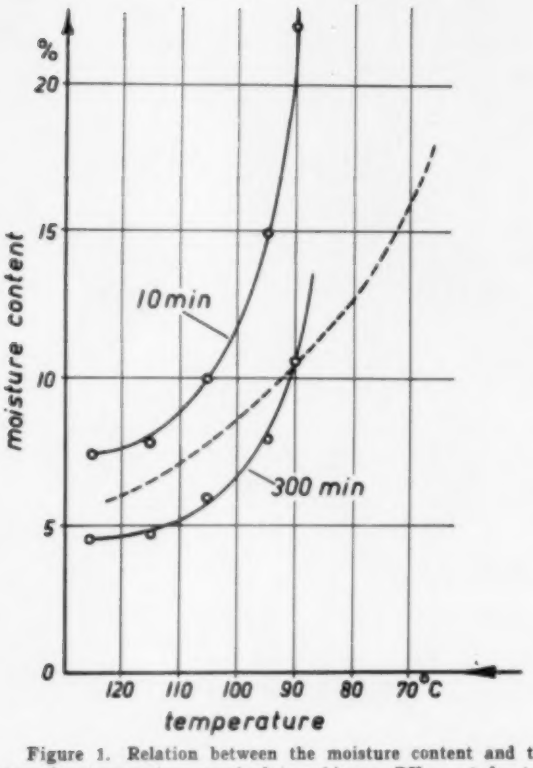

Figure 1. Relation between the moisture content and the steaming temperature required to achieve a $PV_{asc} = 2$ for two different steaming times.

different ways to a $PV_{asc} = 2$ (90° C., 22% moisture content; 95° C., 15% moisture content, 115° C., 7.5% moisture content) were approximately the same when stored at 9% moisture content. Only with the highest steaming temperature was the bitter flavor component more marked from the very beginning than in the other two cases.

Hutchinson *et al. (6)* have shown that free lipase is, in general, to be found only in the pericarp of groats. In tests conducted by this author, scraping of pericarp down to the testa prior to the steaming process did not bring about any noticeable flavor change during storage in comparison with unscraped groats.

INFLUENCE OF THE MOISTURE CONTENT *(5)*

To study this influence, the steam-treated oatmeal was dried to 12 to 13% moisture content in a hygrostat held at 20° C., to 8% moisture content over silica gel, and down to 5% moisture content in a vacuum drying oven at 40° C. Then the products were stored in hermetically sealed flat tins at 30° C.

Figure 2 shows the results of a storage test in which, primarily, the moisture content during storage was varied. This test showed that moisture content is decisive for the keeping qualities of oat products. At 5 to 6% moisture content (equilibrium humidity ϕ about 15%), 6 months' storage at 30° C. brought about only insignificant flavor changes. The flavor changes were noticeable at a moisture content of 8.5 to 9.5% (equilibrium humidity ϕ of about 35 to 40%) already after 2 to 4 months' storage. At moisture contents of 12 to 13% (equilibrium humidity about 70%), a sour or yeasty flavor frequently appeared, although the oat products did not get moldy. One hour's sterilizing of the tins in boiling water only reduces this off-flavor and did not remove it entirely. All flavor changes were more marked when raising the moisture content from 8.5 to 12.5% than by raising it from 4.8 to 8.5%. This is true especially over longer storage periods. Exposure of steamed oatmeal of 5% moisture content to light (kept under glass) showed no marked effects. Neither did the storage of the oats containing 10% moisture content in a nitrogen atmosphere prevent off-flavors.

PRACTICAL TESTS

The laboratory tests reported in previous sections of this paper were followed by a study of the distribution of temperature, moisture content and peroxidase value of oats during the kilning process in a continuous gravity drier. The results for 3 different kilning periods are shown in Figure 3, *(4)*. The homo-

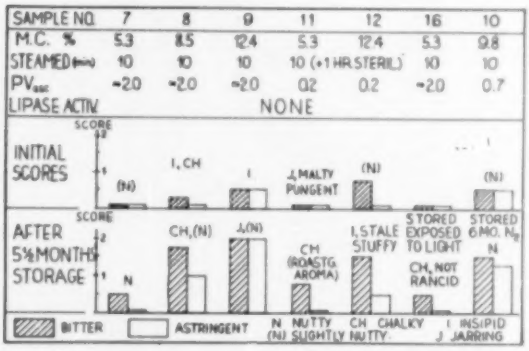

Figure 2. Storage of oatmeal at 68° F. (20° C.) (Steaming at 95° C. and 15% moisture)

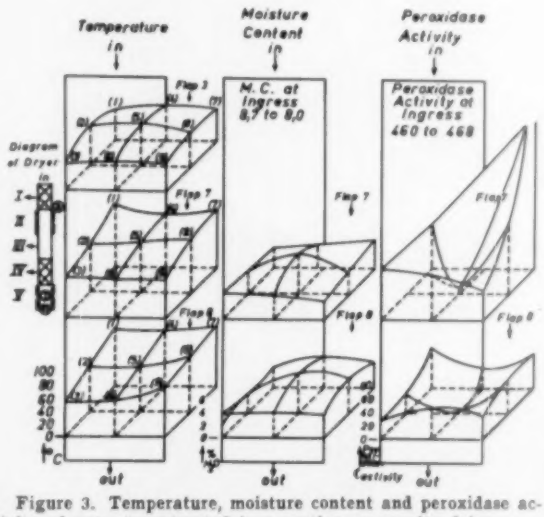

Figure 3. Temperature, moisture content and peroxidase activity of oats steam-treated in a continuous gravity drier.

geneity in the temperature field, moisture content, and peroxidase value is rather disappointing. It is possible by using the peroxidase quick test and by regularly checking the moisture contents, to control the kilning process satisfactorily. One German manufacturer is doing so and thereby avoiding his former persistent failures. But it would seem more to the point to seperate the steam-treating from the kilning process. It is recommended that the wetted oats be steamed in a heated screw at a constant moisture content and then the material be dried in some type of vertical turbo-drier.

ANALYTICAL RESULTS

An attempt has been made to correlate some of the results reported herein with chemical analyses. It has been shown that in the oils of oat meals ground from steam-treated lipase-free oats, the free fatty acids (FFA) increase during storage. It is very probable that an autocatalytic formation of fatty acids takes place according to the relation established by Karon and Altschul *(1)*. On the other hand, the curve of experiment 15 (Figure 4) resembles more an enzymatic reaction, although no lipase activity could be found in the oatmeal sample either before storage or after taking it out of storage.

Some results of attempts made to find correlations between the increase in free fatty acids and the findings of the organoleptic tests are tabulated in Table 2. Since the steamed oats were free from lipase and since, at low equilibrium humidities, mold lipases can scarcely be active, one may conclude that Moran's *(7)* assumption of the lipatic activity being responsible for the increase in FFA and therefore for the bitter flavor cropping up, is not applicable in this case. It is only one of several possibilities.

Finally a check was made to determine whether in storage, apart from the lipolytic changes oxidative changes (fat-peroxide formation) have to be reckoned with also. As a measure of the fat-antioxygenic impedance, Purr's "antioxygenic inhibition time" $(AIT)_{102°\,C.} = t - t_o$ *(10)* was employed. This time value expresses the changes during steaming and storage in the keeping qualities of oils extracted from oat products.[c] Some of the typical results have been reviewed in Table 3. A low moisture content is again very favorable and a high moisture content is rather unfavorable for the fat-antioxygenic "carry-through," whereas a medium moisture content may have a satisfactory or unsatisfactory result. The danger from oxidative rancidity decreases with decreasing moisture content.

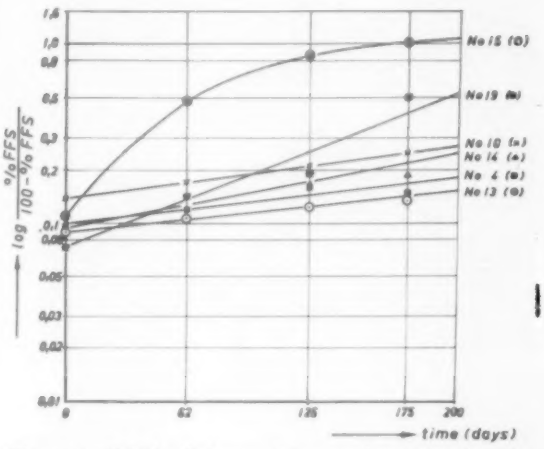

Figure 4. Relation between storage period and a function of the percentage of free fatty acids formed in the oil of steam-treated oatmeals after their storage.

(% FFA = free fatty acid; 100 − % FFA = unhydrolyzed residual oil)
No. 15 was steamed for 20 minutes and stored at 12.7% moisture content.
No. 4, 13 5% moisture
No. 14, 19 8.5% moisture, (No. 19 steamed at 90° C.).
No. 10 10% moisture (Figure 2).
Steaming at 95° C. and 15% moisture. The moisture contents quoted were kept constant during storage.

A concurrent check of the freshness of oat oils after 6 months' storage of oatmeal showed that the freshness limit (PN = 3)[d] was not exceeded for oatmeals made from steam-treated oats. To sum up the results of these tests with steamed oats—excepting the great importance of a low moisture content already mentioned—we have shown the following:

At an equal low resp. medium moisture content $(PV_{asc}) < 2$ generally shows a higher carry-through than $(PV_{asc}) > 2$. A high humidity during storage not only accelerates the formation of an off-flavor, but

[c] t_o is the time necessary to reach PN = 10 at the time of placing in storage and t is the time required to reach the same number when taken out of storage for the third time. $t < t_o$ means a decreased impedance to oxidative rancidity (carry-through).

[d] Peroxide-Number $((PN) = 3\ N/500 \frac{cm^3\ Na_2S_2O_3}{gr.\ dry\ matter}$

TABLE 2

The relationship between the average moisture content of oats and the changes in flavor and free fatty acids during storage

Test numbers	Moisture content at beginning of test	Subjective changes in flavor score		Increase of free fatty acids	Remarks
		Bitter	Astringent		
	%			%	
4; 7; 11; 13; 16; 25; 27	5.2	0.43	0.18	2.13	Far better than the admissible limit of salability.
5; 8; 10; 14; 18; 19; 21; 22	9.1	0.88	0.88	9.97	Just at the lower limit of salability.
6; 9; 15; 26; 28	12.6	1.5	1.4	27.2	Quite bitter or astringent. The limit of salability is reached or passed.

TABLE 3

Variations of the steaming process and their influence on the keeping qualities of oats assessed by fat-antioxygenic "carry-through"

Test No.	Steaming		Moisture content during storage	$AIT_{100°C.} = (t - t_o)$	(PV_{asc})
	Time	Temperature M. C.			
	(min.)		%	*(min.)*	
11	10 (+ 1 hour's sterilization)	95° C./15%	5.3	−8	0.2
6	5	95° C./15%	12.5	−455	13.0
8	10	95° C./15%	8.5	−70	2.0
14	20	95° C./15%	8.4	−230	0.8
25 other variety	5	95° C./15%	5.6	−20	~25
26 other variety	5	95° C./15%	12.6	−280	~25
27 other variety	15	95° C./15%	5.6	−10	~ 1.6
28 other variety	15	95° C./15%	12.6	−200	~ 1.6

impairs the carry-through, the height of (PV_{asc}) being then of no particular importance.

SUMMARY

In summarizing our work, the following results are of technological interest:

1. To obtain oat products free from bitter flavor, a peroxidase test is a good control method. By its use, not only customary complaints about the quality of oat products may be completely stopped, but also a proper control of the steaming and kilning processes can be established. It is advocated to strive for a PV_{asc} of about 2. For some oat varieties higher PV_{asc}'s are admissible. By varying the moisture content and the temperature during steaming in conjunction with a fixed peroxidase inhibition, one may vary the flavor of the oat product and obtain the necessary harmony of flavor and aroma. Based on the investigations reported here, suggestions have been offered for improving the design of drying-kilns for oats.
2. The keeping qualities of oat products during storage are influenced more by the moisture content than by the reduction of the peroxidase activity by the steam treatment. At 5 to 6% moisture content, organoleptic changes during 6 months' storage at 30° C. are still insignificant, but become noticeable at moisture contents of 12 to 13% and after only 6 weeks' storage. The formation of free fatty acids in the steamed oats can, at the moisture level under consideration, not be attributed to lipase activity. It is probably due to an autocatalytic lipolysis. Oxidative rancidity of oat oils is no problem within the storage periods examined for steamed oats. Flaked oats requiring long shelf-life have to be dried to a low moisture content and packed in vapor-tight packages.

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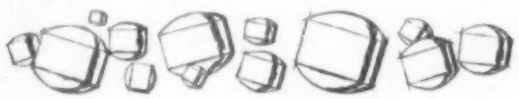

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Comparison of Mass Panel and Household Consumer Responses to Canned Cling Peaches*

(Manuscript received May 31, 1958)

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Marion J. Simone,
Sherman J. Leonard
University of California, Davis
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THE RELIABILITY of the results obtained in a consumer survey is greatly influenced by the techniques and procedures employed. Among the controversial factors often discussed in relation to consumer polls are the type of approach, i.e., mass surveys and household surveys, and the geographic location of the population sampled. Interviewing the public in stores and at large gatherings has been reported by many investigators to give satisfactory results *(3, 5, 7, 8, 9, 16, 19, 20)*. Mass surveys are usually quicker, allow for better control of tasting variables, and are less costly per evaluation than are household surveys. The household interview, however, is preferred by several groups *(1, 4, 7, 10, 11, 18)*. According to Nair *(15)* and Crocker and Sjöstrom *(6)*, the casual passer-by does not make a good judge for determining food preferences since two abnormal conditions exist: (a) the physical environment is atypical; (b) most products are consumed simultaneously with other foods at mealtime rather than singly. Arnold *(1)* stated, "Paired comparisons in the home are known to be subject to many more uncontrolled variables than are the local store tests, but they (home surveys) have the advantage of better representing, on the average, the actual conditions of use."

It is generally believed that regional preferences for specific food items exist in this country. However, little has been reported regarding preferences for foods familiar to consumers in various geographic areas. The present investigation was designed to compare preferences of a California household panel and a midwestern household panel, for three samples of canned cling peaches, as well as to compare responses between mass panels and household panels within a region (California).

EXPERIMENTAL PROCEDURE

Raw material. Diced cling peaches of the Johnson variety were packed under carefully controlled conditions in the pilot plant of the Food Technology Department, Davis *(19)*. Plain tin cans, 401 x 411 (No. 2½) were filled with 20 oz. of diced fruit and 10 oz. of sucrose syrup. Citric acid, at the level of 0.15%, was added to one of the samples. Chemical analyses of the peaches 30 days after canning are shown in Table 1.

California sampling. In addition to obtaining preferences from a trained laboratory taste panel, 3 consumer surveys were conducted. Two mass surveys were held at the California State Fair in Sacramento from August 28 through September 8, 1957. In the first survey, conducted by the University of California, paired samples of peaches were presented in random order to approximately 1,667 participants who indicated their preferences according to a previously described procedure *(16)*. The second sampling, part of the Fair's Consumer Reaction Council, attracted 804 people who indicated their degree of like or dislike for one of the three samples of peaches. Score cards used by these 2 mass survey populations are shown in Figures 1 and 2, respectively.

The household survey was conducted among 225 families in the city of Woodland, California (pop. 12,000 [b]). Each family received a set of instructions and 2 coded cans of peaches. Family members over the age of 10 tasted the peaches at a regular meal and indicated their preferences on the score card provided (Figure 1). The 6 possible paired sets were distibuted randomly and the samples were coded in reverse order in half of the cases to offset any first sample bias. Completed responses were mailed to the survey director.

Participants on the trained laboratory taste panel consisted of staff members of the Department of Food Technology. The panel expressed their preferences between paired samples of peaches on 4 consecutive days, so that a total of 120 separate evaluations was obtained.

Midwest sampling. Peaches from the same pack described above were shipped to The Kroger Food Foundation, Cincinnati, Ohio, for distribution to their Homemakers' Reference Committee of 750 families *(8, 10)*. Families in this group, which was started in 1933, were selected and are maintained according to 3 requirements: (a) representative geographic distribution throughout the territory served by The Kroger Company (19 midwestern states); (b) high, medium and low income brackets represented by the latest available statistics; (c) distribution of ages within the group corresponding to the latest census figures.

TABLE 1
Chemical composition of canned cling peaches

Samples	A	B	C
Cut-out Brix [1]	24.24°	26.98°	27.59°
Total acidity [2]	0.279	0.277	0.408
pH	4.06	4.12	3.78
Brix acid ratio	86.89	97.82	67.74

[1] Soluble solids measurement of pulped peaches and syrup by refractometry.
[2] Reported as % citric anhydride.

* Presented at the Eighteenth Annual Meeting of the IFT, Chicago, Illinois, May 27, 1958.

[b] Based on a study of the Woodland market made in a previous consumer survey *(21)*, the distribution of the city population by yearly family income was: 16% earned less than $3,000; 76% earned between $3,000 and $10,000; and 8% were in the over $10,000 income bracket. These percentages are similar to available income estimates for Sacramento, Modesto and Fresno, California *(12)*.

Figure 1. Individual score card used in the California household and mass surveys.

Code No._____

Please complete the following:

Sex:	Age:	PREFERENCE: (check only one)
Male_____	Under 16____	
Female_____	16-24 ____	I prefer Sample W-7_____
Meal:	25-39 ____	
Morning_____	40-59 ____	I prefer Sample X-6_____
Noon_____	Over 60 ____	I have no preference_____
Evening_____		

Use reverse side for comments

Thank you.

Figure 2. Single sample evaluation score card.

California State Fair and Exposition
Consumer Reaction Council
Score Sheet

Under 18	_____
18-40	_____
Over 40	_____
Male	_____
Female	_____
Married	_____
Unmarried	_____
Live in City	_____
Live on Farm	_____
Do not like it at all	_____
Do not like but will eat it	_____
Like it a little	_____
Like it very much	_____

Is this a food you eat regularly?
Yes or No _____

Comments:

For this survey, the families were grouped and sent paired samples of peaches according to the following plan:

	First mailing	Second mailing
Group X (1/3 committee)	A–B	B–C
Group Y (1/3 committee)	A–C	A–B
Group Z (1/3 committee)	B–C	A–C

A detailed set of instructions requested that the peaches be served cold, as part of a regular family meal and that a specified sample be tasted first. Within each group, half of the families received samples coded in reverse order to off-set any first sample bias. The score sheet employed is shown in Figure 3. Questions pertaining to frequency of consumption and prices were asked of the California household panel, also.

Significant differences in preferences (excluding "no preference," "neither," and "no answer") were determined by the method of "chi-square," using Yates's Correction for continuity *(23)*.

RESULTS AND DISCUSSION

A distribution by age and sex of the 7,108[c] participants on 5 taste panels is shown in Table 2. Without exception, more females than males were interviewed, especially in the mass survey using the single sample presentation. An exceptionally large number of children were attracted to the mass surveys whereas, at the household level, a distribution more representative of the total population was observed.

Tabulation of the midwestern opinions (Table 3) disclosed definite flavor preferences between the paired samples. With the exception of Sample C being significantly preferred over B, the appearance of the samples were considered comparable. This is further evidenced by the very large number of "no preferences." A similar manifestation is seen in the preferences for "eating quality." In the remainder of this paper, only flavor preferences from the midwestern group will be discussed.

Over-all preferences. In Table 4, over-all preferences are presented as percentages to afford easier comparison. Sample C (27.59° Brix and 0.408% acid) received the greatest number of preferences when evaluated in the home whereas all samples were almost equally well liked by the laboratory and two mass survey panels. These results agree with a previous preference for cling peaches of a 26.3° Brix and 0.483% acid content *(20)*. Significant preferences were obtained from the midwestern group for each of the 3 paired comparisons. In all comparisons, the sample with the greatest amount of sugar was preferred. This group also showed the largest number of "no preference" responses. When evaluated singly, the samples were identical in acceptability.

The inability of the laboratory panel to establish preference trends emphasizes the often-voiced opinion that costly, erroneous conclusions can result from predicting consumer acceptance on the basis of laboratory preferences.

Effect of age and sex. Classified by age (Table 5),

[c] Different totals may appear throughout the paper as all score cards were tallied despite incompleted answers to some of the questions.

TABLE 2

Age and sex distribution of taste panel participants (7,108 participants)

Age group	Paired sample methodology							Single sample methodology	
	Household survey				Mass survey		Laboratory panel	Mass survey	
	Midwest		California		California		California	California	
	Male	Female	Male	Female	Male	Female		Male	Female
Under 16	280	266	92	96	378	292		192	225
16–24	193	227	18	30	136	169		71	186
25–39	282	366	97	102	145	231			
40–59	623	820	98	95	88	156		30	100
Over 60	353	447	33	39	11	31			
Total	1731	2126	338	352	758	879	120	293	511

TABLE 3

Midwestern responses to quality factors in cling peaches (values represent numbers of individuals)

Quality factor	Pair	Preference for indicated samples			No pref.	Neither	No ans.
		A	B	C			
Appearance preference	AB	430	403		577	41	35
	AC	410		460	502	35	16
	BC		327	491 [3]	467	33	21
Flavor preference	AB	538	641 [2]		251	18	38
	AC	494		685 [3]	187	25	32
	BC		483	595 [3]	216	10	35
Eating quality preference	AB	427	419		556	36	48
	AC	444		535 [1]	405	18	31
	BC		427	471	375	18	48

[1] Significant preference at the 5% level of probability.
[2] Significant preference at the 1% level of probability.
[3] Significant preference at the .1% level of probability.

Figure 3. Kroger Food Foundation's score card.

	SEX		AGE					TIME OF SERVING		
Family Member	Male	Female	Under 16	16–24	25–39	40–59	Over 60	Morning	Afternoon	Evening
1										
2										
3										
4										
5										
6										
7										

Have each family member taste the sample coded "red" first, but after they have observed both samples record their opinions on appearance, flavor and eating quality below.

	APPEARANCE PREFERENCE				FLAVOR PREFERENCE				EATING QUALITY PREF.			
Family Member	Red	No Pref.	Green	Neither	No Pref.	Red	Neither	Green	Neither	Green	Red	No Pref.
1												
2												
3												
4												
5												
6												
7												

Note: No Pref. = No preference for either sample.

The following questions are to be answered only by the homemaker:

1. Do you serve canned peaches:

   More than once per week _____

   More than once per month _____

   More than once per year _____

   Never _____

2. If the sample coded RED cost 5 cents per can more than the sample coded GREEN, which would you buy?
   Red_____ Green_____ Either_____ Neither_____

3. If the sample coded GREEN cost 5 cents per can more than the sample coded RED, which would you buy?
   Green_____ Either_____ Neither_____ Red_____

4. If both samples cost the same, which would you buy?
   Either_____ Neither_____ Red_____ Green_____

TABLE 4

Over-all preferences for cling peaches by five panels (Percent preference)

Paired comparison-preference

Household survey

Midwest

Pair	No. Eval.	A	B	C	NP [1]
AB	1430	37.6	44.8 [3]		17.6
AC	1366	36.2		50.1 [4]	13.7
BC	1294		37.4	45.9 [4]	16.7
Total	4090	25.2	27.5	31.3	16.0

California

Pair	No. Eval.	A	B	C	NP
AB	236	49.6	41.9		8.5
AC	235	44.3		47.7	8.0
BC	219		28.8	61.2 [4]	10.0
Total	690	32.0	23.5	35.7	8.8

Mass survey

California

Pair	No. Eval.	A	B	C	NP
AB	616	49.7	42.5		7.8
AC	567	47.8		45.7	6.5
BC	518		41.9	51.9 [3]	6.2
Total	1701	33.9	28.2	31.0	6.9

Laboratory

California

Pair	No. Eval.	A	B	C	NP
AB	40	52.5	40.0		7.5
AC	40	47.5		50.0	2.5
BC	40		50.0	45.0	5.0
Total	120	33.3	30.0	31.7	5.0

Single sample

Mass survey

(average scores)

California

No. Eval.	A	B	C
804	3.87	3.82	3.84

[1] No preference.
[3] Significant at the 5% level of probability.
[4] Significant at the 1% level of probability.
[4] Significant at the .1% level of probability.

there were 7 significantly different comparisons for the midwestern panel, 4 for the California household panel and only 1 for the mass survey group. Undoubtedly, the number of individuals involved within each category influenced the statistical treatment of the data. Consumers under 25 had fewer decided preferences whereas those between 40 and 59 were more opinionated. Baten *(6)* reported that young people could distinguish differences between various strengths of material when more mature individuals could not, but he gave no information on preferences.

Classification of the data by sex (Table 5) suggests that females were more definite in their preferences than were males. Totals denote that when interviewed at home, both sexes preferred Sample C; in the mass survey, males had a slight preference for Sample B and females definitely preferred Sample A. Past surveys *(16, 19, 20, 22)* have shown tendencies for men to give less homogenous responses as a group and to prefer sweeter samples than did women.

Order of presentation. All the populations sampled were influenced to some degree by the order in which they tasted the peaches (Table 6). The midwestern panel was very strongly affected while there was little variation in the California preferences. Many investigators have commented on the phenomenon of first-sample bias *(3, 13, 14, 15, 16, 19, 20)*.

Frequency of consumption. In Table 7 is demonstrated one of the most outstanding differences between the household panels and the mass panel, the frequency of consumption distribution. More than half (58%) of the 1,701 participants in the mass survey reported they consumed canned peaches [d] more than once per week. It is possible that the large number of children who participated in the latter survey only ventured a guess and that the frequency reported by the homemaker in the household surveys represented a truer response.

Time of day of consumption. Information regarding the meal at which the peaches were tasted was collected only at the household level (Table 8). More significant differences were obtained from the evening tasters where larger numbers were represented. A larger percentage of Californians sampled their peaches in the evening with only 9.7% of this group eating the fruit for breakfast. Time of day did not appear to influence the total preferences of either group. Peryam *(17)* found significant differences in preference for orange juice when served at different meals.

Price and preference. Neither Californian nor Midwestern homemakers were willing to pay 5¢ per can extra for the samples they preferred (Table 9). A relatively large percentage of the midwestern families indicated they would purchase either sample. When both samples cost the same, Sample C, which is commensurate with their over-all preference, would be purchased.

It should be pointed out that the actual cost of adding citric acid and more sugar to the canned peaches was considerably less than 5¢ per can. Calculated on the basis of sugar costing $9.38/100 lbs. and citric acid costing $40.69/100 lbs., sample B cost $0.12 per case (24 No. 2½ size cans) more than sample A; sample C cost $0.16 per case more than sample A. These figures included materials only, ignoring any additional costs of handling, labor, lowered drained weights which might require additional fruit, etc.

SUMMARY

Three samples of canned cling peaches varying in sugar content (24.2°, 27.0°, and 27.6° Brix) and/or total acidity (0.279% and 0.408% citric) were evaluated by 3 consumer populations and a laboratory panel in California and by The Kroger Foundation's Homemakers' Reference Committee distributed throughout 19 midwestern states. When judged by mass survey techniques, using the method of paired-comparison preference, the 3 samples were almost equally well liked. At the household level, both the California group and the Kroger committee demonstrated a sig-

[d] The question did not distinguish between freestone and clingstone peaches.

TABLE 5

Distribution of preferences by age and sex
(values represent numbers of individuals)

Age	Pair	Household survey						Mass survey		
		Midwest			California			California		
		A	B	C	A	B	C	A	B	C
Under 16	AB	67	78		33	28		122	109	
	AC	87		92	23		31	91		106
	BC		71	84		21	36 [1]		79	109 [1]
	Total	154	149	176	56	49	67	213	188	215
16–24	AB	60	57		8	7		56	42	
	AC	48		71 [1]	12		5	51		48
	BC		47	61		2	7		49	43
	Total	108	104	132	20	9	12	107	91	91
25–39	AB	88	88		38 [1]	23		65	57	
	AC	88		119 [1]	26		36	77		63
	BC		82	99		17	47 [2]		50	61
	Total	176	170	218	64	40	83	142	107	124
40–59	AB	189	234 [1]		33	36		53	49	
	AC	162		236 [2]	34		24	46		34
	BC		161	204 [1]		17	37 [2]		29	44
	Total	351	395	440	67	53	61	99	78	78
Over 60	AB	110	128		5	5		10	5	
	AC	78		130 [2]	9		16	6		8
	BC		77	127 [2]		7	6		5	12
	Total	188	205	257	14	12	22	16	10	20
Male	AB	231	240		56	50		122	139	
	AC	198		278 [3]	44		58	105		108
	BC		187	268 [3]		33	62 [2]		99	117
	Total	429	427	546	100	83	120	227	238	225
Female	AB	283	345 [1]		60	49		184 [2]	123	
	AC	265		370 [3]	60		54	166		151
	BC		251	307 [1]		31	72 [3]		118	152 [1]
	Total	548	596	677	120	80	126	350	241	303

[1] Significant at the 5% level of probability.
[2] Significant at the 1% level of probability.
[3] Significant at the .1% level of probability.

TABLE 6

Effect of order of presentation
(Number of individuals)

Order of presentation 1st 2nd	Household survey						Mass survey		
	Midwest			California			California		
	A	B	C	A	B	C	A	B	C
A – B	258	272		57	51		152 [1]	110	
B – A	256	313 [1]		60	48		154	152	
A – C	254		289	57		48	141		128
C – A	209		359 [3]	47		64	130		131
B – C		236	225		27	71 [3]		124	133
C – B		202	350 [3]		36	63 [3]		93	136 [2]

[1] Significant at the 5% level of probability.
[2] Significant at the 1% level of probability.
[3] Significant at the .1% level of probability.

TABLE 7

Frequency of consumption of canned peaches

Frequency	Household surveys		Mass survey
	Midwest	California	California
	1,274 families	217 families	1,701 participants
	%	%	%
Weekly	26.2	23.6	58.0
Monthly	62.1	57.2	37.7
Yearly	10.2	14.2	4.2
Never	0.9	3.6	0.1
No answer	0.6	1.4	0

nificant preference for the sample with a sugar content of 27.6° Brix and acidified to 0.408% citric acid. Neither Californian nor Midwestern homemakers expressed a willingness to pay 5¢ per can extra for the samples they preferred.

The mass survey type panel which tasted the fruit in a single sample presentation indicated they liked all three samples equally. It is felt that more reliable responses were obtained from the household panels than from the mass panels. Laboratory panel preferences were unreliable as a guide for predicting consumer preferences. The effects on preference of age, sex, time of day and frequency of consumption of peaches are presented.

Acknowledgments

Appreciation is extended to the members of the Department of Food Technology and The Kroger Food Foundation who

TABLE 8

Effect of time of day of consumption—household panels (values represent numbers of individuals)

Time of day	Pair	Midwestern panel				California panel			
		A	B	C	No pref.[1]	A	B	C	No pref.[1]
Morning	AB	92	94		48	12	12		0
	AC	91		101	43	7		13	4
	BC		69	120 [2]	47		7	8	1
	Total			705	(17.2%)			64	(9.7%)
Noon	AB	169	166		58	20	13		2
	AC	100		89	60	13		19	3
	BC		127	165 [2]	57		5	12	2
	Total			991	(24.2%)			89	(13.4%)
Evening	AB	285	345 [2]		151	78	72		17
	AC	316		410 [2]	107	81		78	11
	BC		272	370 [2]	137		47	107 [2]	18
	Total			2,393	(58.6%)			509	(76.9%)

[1] Combination of "Neither" and "No Preference."
[2] Significant at 5% level of probability.
[3] Significant at .1% level of probability.

TABLE 9

Influence of price on buying behavior—household surveys (values represent numbers of families)

	Preferences			
	Sample	Sample	Either	Neither
I. If A cost 5¢ more than B	A	B		
Midwest	93	238 [3]	83	11
California	33	35	2	2
II. If B cost 5¢ more than A	A	B		
Midwest	227 [2]	106	88	10
California	35	33	2	2
III. If A cost 5¢ more than C	A	C		
Midwest	106	244 [3]	61	10
California	36	31	1	3
IV. If C cost 5¢ more than A	A	C		
Midwest	205 [2]	126	74	12
California	34	34	2	3
V. If B cost 5¢ more than C	B	C		
Midwest	89	221 [3]	84	7
California	19	45 [1]	2	3
VI. If C cost 5¢ more than B	B	C		
Midwest	187 [2]	120	88	8
California	41 [1]	23	2	3
VII. If A cost the same as B	A	B		
Midwest	148	166	113	8
California	33	35	4	2
VIII. If A cost the same as C	A	C		
Midwest	144	191 [1]	83	8
California	37	36	1	0
IX. If B cost the same as C	B	C		
Midwest	130	172 [1]	96	8
California	20	46 [1]	3	0

[1] Significant preference at 5% level of probability.
[2] Significant preference at 1% level of probability.
[3] Significant preference at .1% level of probability.

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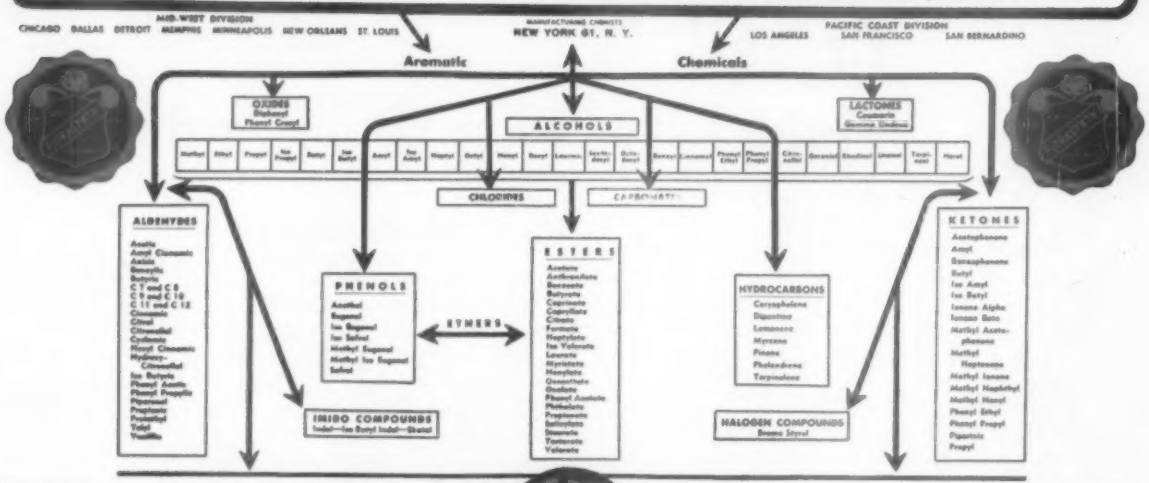

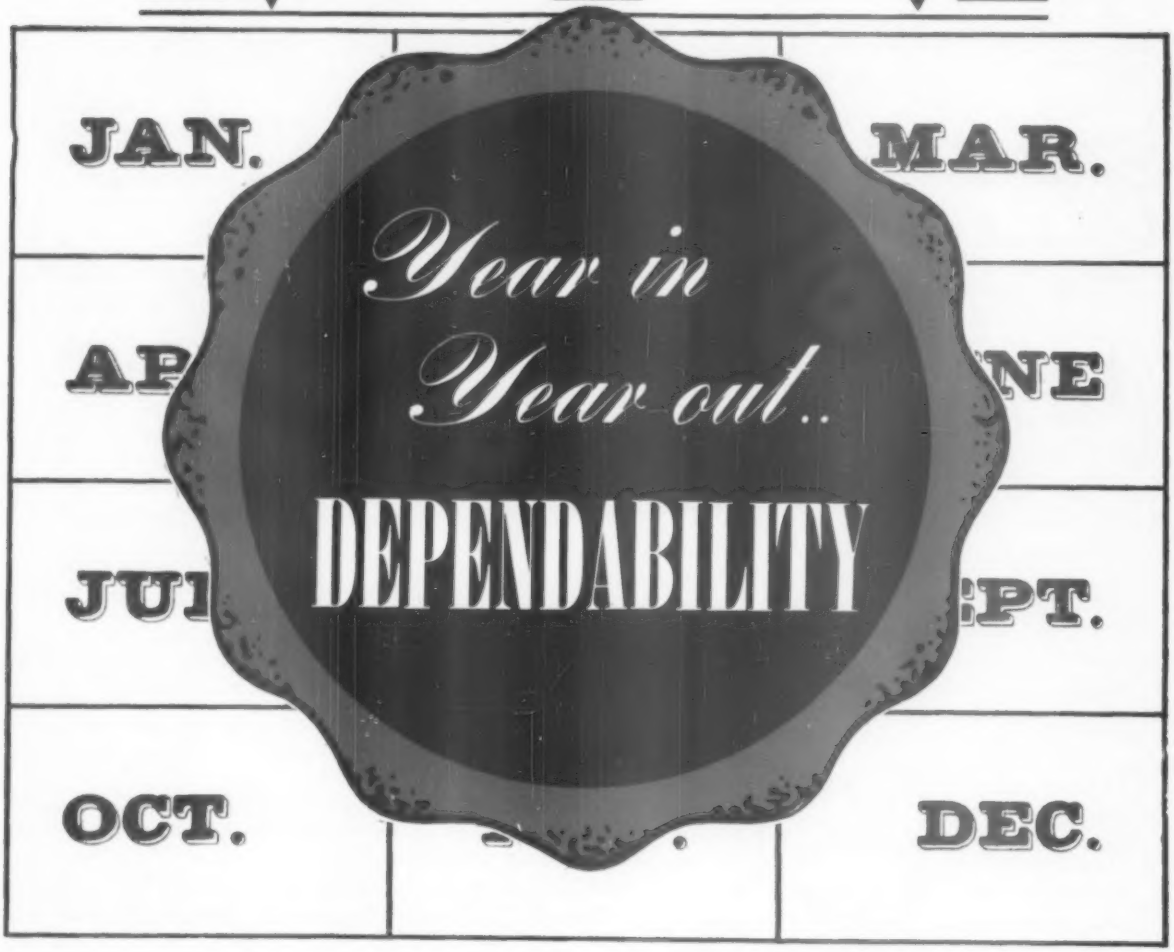

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Notes and Letters

Prepared Foods for Military Use (British Army)*

THE BRITISH ARMY, in common with the American and Canadian, is anxious to obtain foodstuffs which are light in weight and small in volume. It is intended that these foods be prepared by soldiers who are not expert cooks to provide a satisfactory main meal, either by immediate reconstitution in hot water or by boiling or simmering for less than 15 minutes. For some time the Ministry of Agriculture, Fisheries and Food's Research Establishment at Aberdeen, Scotland, has been interested in developing this type of foodstuff. During the last two years this project has received increasing emphasis.

The Aberdeen factory, a research establishment which was designed specifically for work on dehydration connected with Service problems, contains laboratories for research and development and has also two factory bays, fully equipped for investigating dehydration. One of these bays has been devoted almost exclusively to improving the methods of drying vegetables by using hot air. Many improvements in existing techniques have resulted. In addition, the engineers on the staff have developed new and better equipment.

The other bay has been used to investigate dehydration, particularly of meat and fish, by the vacuum contact plate drying method, a method originally developed for drying and empressing fish fillets. By this procedure, water is easily removed from the tissue, partly because it operates under a vacuum and partly because the material is sandwiched between movable heating plates. These plates, during operation, can be brought together to maintain good thermal contact throughout the whole drying process.

The first attempt to prepare pre-cooked dehydrated foods was to cook a meal by the normal technique and mix the ingredients in a normal ratio. The mixture was then dehydrated by the vacuum contact drying process. Examples of material prepared in this way were beef stew, curried mutton, ham and beans in tomato sauce, minced pork with spaghetti, and macaroni cheese. The beef stew was compressed to reduce the volume. All these products reconstituted fairly readily and had a shelf life of some 4 to 6 months except for macaroni cheese which kept even longer.

The next logical step was to dehydrate individual ingredients. This was done with meat and fish. Successes in this field were: raw sausage meats, cooked ham as mince or dice, minced cooked liver, minced cooked kidney, cooked beef chunks, minced cooked chicken, flaked cooked kipper and cooked shrimps. It would obviously have been desirable if these products could have been compressed but unfortunately most of them were too brittle.

FREEZE DRYING

About this time a new method of dehydration was developed in Aberdeen. This is the accelerated freeze-drying method which takes approximately one-quarter of the time of the normal freeze-drying method. Nevertheless, the product is indistinguishable from classical freeze-dried material and reconstitutes as readily. The low temperatures minimize tissue damage and losses in nutrients.

Briefly, the procedure, which was adapted from vacuum contact plate drying, is to freeze the material, slice it to an appropriate thickness, load the frozen tissue into the plant and exhaust to 1 mm. absolute pressure. Once an outer structure of freeze-dried material is established, the plate temperature is increased to 90° C. to ensure more rapid evaporation. Then, as the inner tissue approaches dryness, it is allowed to fall again to 60° C. At this time the temperature of the material is rising and half an hour after they converge at 60° C. the process is complete.

This accelerated freeze-drying process has been applied successfully to a wide range of products. One example is cooked dehydrated fish fillets. These can be mixed with mashed potato powder, herbs, spices and condiments to form a fish-cake mix (the fish fillets themselves are too fragile to use alone). The fish-cake mix reconstitutes instantly in warm water and then can be reshaped and fried. Cooked meats have been sliced or cubed and, if very lean, dry in 6 hours at temperatures between 60–80° C. However, if there is much fat present, as for example in pork chops, the temperature should not exceed about 40° C. The drying takes 7 hours. Slices of cooked meat, one-third of a centimetre thick, have been dried in multiple layers. They separate easily and after reconstitution can be served cold or covered with hot gravy. An oxtail soup has also been made. Veal and chicken mince and chicken pieces have also proved very acceptable.

Although the AFD process is not quite so essential for vegetables, which can be satisfactorily dehydrated by hot air, peas and green beans have been prepared with advantage by this method. They are extremely porous, reconstitute readily and cook in 15 minutes. Flaked vegetables have been dried in air. They reconstitute in 5 to 10 minutes and when mixed with a meat mince, can be used to form a meat and vegetable block, thus providing a rapidly reconstituted stew.

* Presented at the Eighteenth Annual Meeting of the Institute of Food Technologists, Chicago, May 26, 1958.

As yet the progress with fruits has not been so rapid but a very palatable apple and sugar mix which reconstitutes in 3 to 5 minutes has been prepared.

PACKAGING

One of the problems which has yet to be completely overcome is that of packaging the dehydrated material. Most of the products which have been prepared in Aberdeen have been vacuum packed, either after compression or uncompressed. Pliable plastic pouches have been used, but in certain instances, such as with flaked vegetables and meat cubes, the sharp edges have perforated the pouch. For some years triple laminated pouches, containing a layer of aluminium foil, have been used successfully for vacuum packing.

Examples of the smaller packs which have been made using these pouches are beef, pork, ham-and-veal and chicken minces. Some of these have been mixed with chicken pieces, and others with curried rice. The fishcake mix with 15% hydrogenated vegetable fat can be compressed and has proved very satisfactory. One of the striking examples of the advantages to be gained from using a plastic pouch instead of a can is that 51 lb. of fresh material, which reduces to 17½ lb. on dehydration, requires only 1½ lb. of pouch.

DEHYDRATED MEAT BAR

One of our staple items for rapidly prepared meals is the meat bar which is prepared from a mixture of equal parts dehydrated, minced, cooked beef and pork with added fat, salt and monosodium glutamate. The mixture is compressed into blocks and vacuum packed into foil laminated pouches.

The method of preparation is to cook the meat by pre-boiling in water. The gravy is run off, concentrated by evaporation in open pans, and mixed with the minced cooked meat. The product is then dried.

Recent studies in Aberdeen have shown that, apart from the loss caused by cooking, there has been no loss of vitamins during the drying process. No loss of nicotinic acid, riboflavin, or vitamin B_{12} is found during 12 months' storage at high temperatures, but the thimaine is lost almost entirely and some loss of pantothenic acid occurs.

The meat bar will store for about two years in the tropics and when vacuum packed in a foil package it is a stable product.

OTHER RAPIDLY PREPARED FOODS

Reverting to the other AFD products, ration packs have been made up from them and trials with 24-hour ration packs have been made recently. In each case the subject lived entirely on the rapidly prepared meals for 4 days. The packs contain various products of ham, beef, mutton and chicken, together with a variety of vegetables, a fish mix, puddings and cheese. The comments from the subjects were very favourable except that they preferred a more solid diet containing more meat and vegetables to some of the fancier items.

The latest development of this work is to prepare 900 lightweight rations. Each ration will be suitable for five men. A variety of foods are included. Two typical menus are: (1) meat rissoles, beans in tomato sauce, curry and rice blocks, and meat paste, (2) egg and cheese, cooked lamb chunks, gravy and onion mix, peas, carrots, mashed potato powder, fruit, milk pudding mix, macaroni and cheese.

New developments in this field have been proceeding rapidly during recent months and many foodstuffs have now been prepared which can either be reconstituted instantly in hot water and are then ready to eat, or which only need cooking for periods of time varying from 3 to 15 minutes. Such developments should be of real value in indicating the directions along which we can hope to effect major improvements in the production of rapidly prepared foods.

H. R. Hinton
British Joint Services Mission
British Embassy Annex
Washington, D. C.

July 15, 1958.

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FOOD TECHNOLOGY

An Official Publication of
The Institute of Food Technologists,
The Professional Society of Food Technologists

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Institute of Food Technologists

The Institute of Food Technologists, the professional society of Food Technologists, numbers among its active members leading scientists, technologists and engineers in the field of Food Technology.

The Institute invites your professional association with this select group of scientific and technological workers. Only those who are qualified by education, special training, or experience are extended this invitation.

Food Technology may be defined as the application of science and engineering to the production, processing, packaging, distribution, preparation and utilization of foods. Scientists, technologists and engineers engaged in Food Technology, executives, officials and supervisors under whose jurisdiction Food Technology operations are conducted, research investigators, teachers, and others working in the field of Food Technology, will find membership in the Institute worth many times its modest cost.

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OBJECTIVES

The Institute is a non-profit, professional, educational association to promote the application of science and engineering to the production, processing, packaging, distribution, preparation, and utilization of foods; it stimulates investigations into technological problems arising therein, it provides a medium for presenting and discussing the results of such investigations; it stimulates and provides means for the free interchange of technological information and ideas among food technologists; it promotes recognition of the role of food technologists in the technical direction of operations in these fields; all of these activities have the ultimate objective of providing better and adequate foods for mankind.

ORGANIZATION AND PROGRESS

Orgapized July 1, 1939, at Cambridge, Mass., with a membership of less than 100, the Institute has grown to more than 5,900 (1958). It is world-wide is scope, with members in North, Central, and South Americas, the Scandinavian countries, England, Holland, Germany, France, India, Australia, and New Zealand.

MEMBERSHIPS

Professional Members. Any person who is ethically qualified, and who has had training and experience in food technology, or any person who in the opinion of the Council is recognized as distinguished in the contributing sciences as they apply to foods, shall be eligible to be a Professional Member of the Institute. The minimum training which shall qualify a candidate for eligibility for Professional Member is, in general, graduation from a college, university, or similar institution in which he has majored in one or more of the sciences or branches of engineering associated with food technology. The minimum experience shall be three years experience in food technology. The Council may, at its discretion, waive any or all of the foregoing requirements in the case of a person who, thru long experience has distinguished himself in the field of food technology.

Members Any ethically qualified person, active in special or limited aspects of food technology, who is an administrator, director or executive under whose jurisdiction operations in food technology are conducted; or who is engaged in the dissemination of knowledge of food technology; or one whose work requires a general knowledge of the broad principles of food technology as it applies to the products, processes or equipment with which he or she is concerned; or one scientifically trained in and who has entered a career in food technology; shall be eligible to become a Member.

Student Members. Any ethically qualified person who has never been a Professional Member or Member of the Institute, who is registered as a student in an educational institution with at least Junior (third year) standing, who is a candidate for a Bachelor's or higher degree in one or more of the sciences or branches of engineering associated with food technology, shall be eligible for membership as a Student Member. This classification shall be his status only until the end of the calendar year in which he completes his schooling. When graduated and otherwise qualified as defined in the section on "Members," a Student Member may, upon application, be elected to Membership.

DUES

Professional Members and Members—$10.00 per year; Students—$2.50 per year. Dues include a subscription to Food Technology.

PUBLICATIONS

Food Technology, issued monthly, is the official journal of the Institute. It is published to advance the profession of food technology by disseminating the results of research and their practical application in industry. Contributors to its pages represent many fields of scientific and technological interest.

Food Research, published bi-monthly, is devoted to publication of the results of original investigations and occasional reviews in the fields of food and beverage technology, chemistry, and microbiology. Food Research is available to Institute members at the special rate of $7.50 per year.

REGIONAL SECTIONS

Where sufficient members (25 or more) live within commuting distance of a given point, a Regional Section may be established. Such Sections are able to hold meetings at more frequent intervals than the National group, thus affording the food technologists regular opportunities for an xechange of views and ideas with others in the area. There are presently 31 Regional Sections.

ANNUAL MEETINGS

Each year one of the regonal sections acts as host to the Institute at an annual meeting. The program of this annual conference is designed to acquaint members with various phases of food production, processing and distribution, and to keep them abreast of current trends and technological developments. The speakers invited are those whose subjects will build a well-rounded program, of interest to the greatest number. Annual conferences are highlighted by exhibits of new equipment, processes and special ingredients.

AWARDS

The society administers the following awards:

NICHOLAS APPERT AWARD (Medal and $1000), Each year the Institute makes this award to a person whose contributions to the food industry make him distinguished and outstanding in the opinion of the national jury.

BABCOCK-HART AWARD ($1,000.00). The purpose of this award, made by the Nutrition Foundation, is to encourage contributions to Food Technology which will have an influence on the nutritional well-being of the general population.

FLORASYNTH FELLOWSHIP AWARD. $1,000 granted annually to a young man or woman under 35 years of age, engaged in senior undergraduate or graduate work, as a candidate for an advanced degree, in recognized educational institutions in the United States or Canada, which is conducting fundamental investigations for the advancement of Food Technology.

GENERAL FOODS FELLOWSHIP AWARDS. Three Fellowships will be granted annually—no more than two to the same educational institution for the same calnedar year, but will be renewable upon application to and approval by the Awards Committee of the Institute for a maximum of three years, in order to provide for continuity of studies leading to a doctorate degree. if the candidate so plans. However, candidates who plan only a year of research after obtaining the Bachelor Degree, or who plan to read for a Master's Degree, will not be excluded from these fellowship grant. Each Fellowship is worth approximately $4,000.

GERBER'S INSTITUTE OF FOOD TECHNOLOGISTS UNDERGRADUATE AWARDS. Six undergraduate Scholarships at $1000 each, per year, intended to cover the last two school years leading to a Bachelor's degree in Food Technology, Food Engineering, or Food Science.

THE SAMUEL CATE PRESCOTT FELLOWSHIP. An engrossed plaque and $1000 granted annually to an outstanding young man or woman of any nationality engaged in senior undergraduate or first year graduate work in the general field of food science and food technology, at a recognized educational or research institution in the United States or Canada. The award is for one year and is not renewable.

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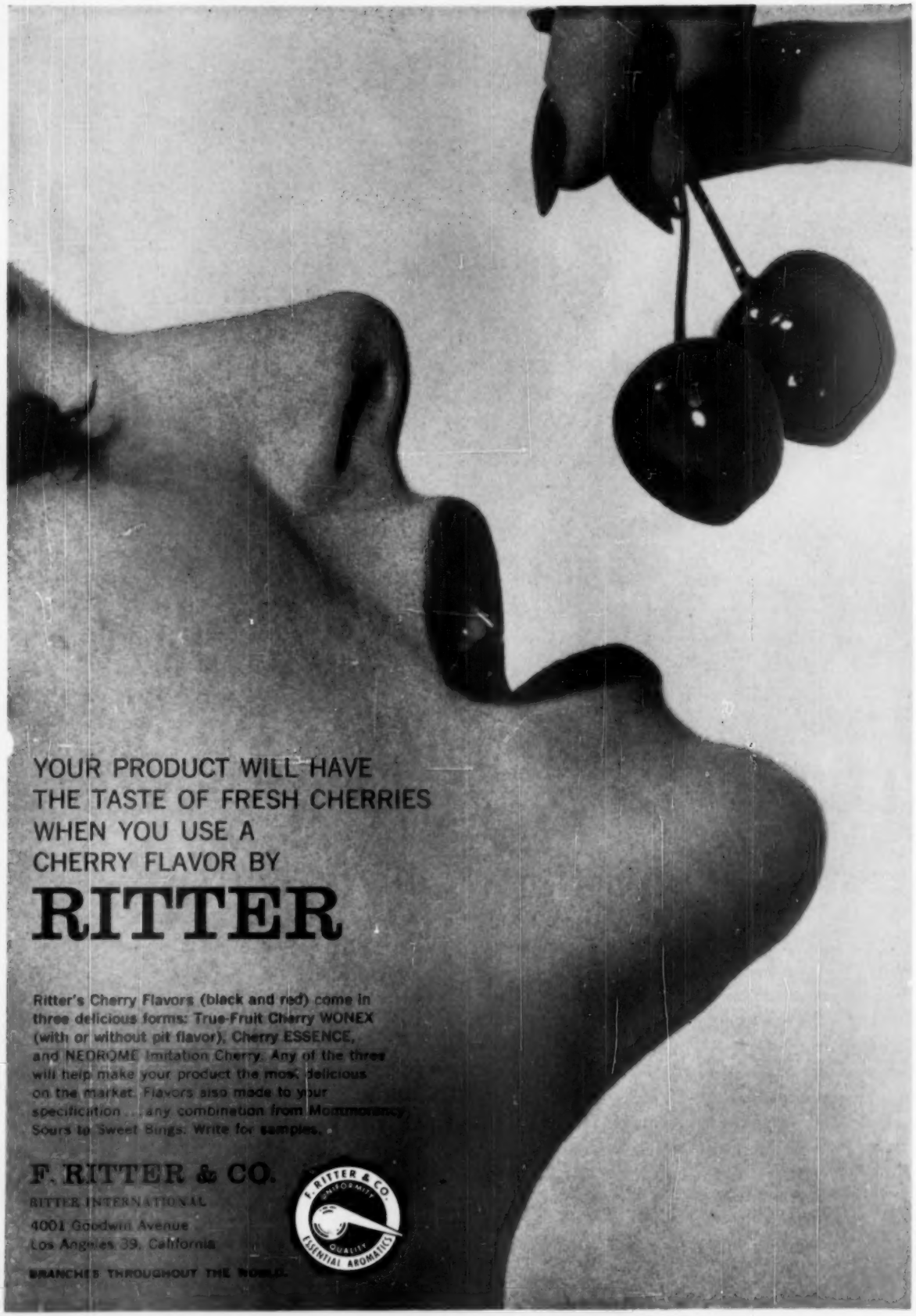
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(Continued from page 12B)

for finding out what the consuming public is likely to do about a new product. It is clear that it will do some strange things. Dr. Garnatz reports that a remarkably faithful imitation of strawberry flavor got nowhere in competition with a synthetic flavor of only modest merit. Eugene Pettersen gives seven suggestions for keeping ahead of competition that would appear to be worthy of a place under the glass of every sales executive's glass top desk.

The final section of the book is devoted to physicochemical research. In the 111 pages devoted to this subject the reader will find a mosaic of articles that will inform him of the efficacy of new instruments and techniques. The results of flavor research on specific commodities indicate the progress being made in identifying the flavor-carrying compounds that characterize specific products.

Dr. A. J. Haagen-Smit's summation of the contributions to flavor research represents, as usual, much more than a mere recounting of each author's data and main points. It is an interpretative essay that leaves the reader with a sense of the difficult path ahead but not without hope that the obstacles will eventually be removed and the mysteries of flavor laid bare.

Flavor Research and Food Acceptance is already, a few months after publication, in lively demand. It is a substantial book and is obviously fulfilling an urgent need.

MARTIN S. PETERSON, Chicago

LITERATURE ON FOOD RESEARCH AND TECHNOLOGY[1]

Commodities

Danish Meat Research Institute. Annual report, 1957. Roskilde, Denmark, 1958. 18 p. processed. Report in English of the Slagteriernes Forskningsinstitut summarizing results of experimental work.

Use of pediococcus cerevisiae starter culture in pork roll. Franklin Mills, and George D. Wilson. Chicago, 1958. 13 p. (American Meat Institute Foundation. Bulletin no. 38.) pap. apply.

Our daily bread. E. J. Pyler. Siebel Publ. Co., Chicago, 1958.

Food Technology

Food and container problems of the armed forces. Chicago, Research and Development Associates, Food and Container Institute, Inc., 1819 W. Pershing Road, 1958. 50 p. pap. apply. An outline of problems, as seen by the Quartermaster Food and Container Institute for the Armed Forces, where industry research findings could be useful in attaining solutions.

Microbiology of fish and meat curing brines. Proceedings of Second Symposium on Food Microbiology, April 1957. Ed. by B. P. Eddy for Department of Science and Industrial Research, Food Investigation. London, Her Majesty's Stationery Office, 1958. 342 p. pap. 45 s. Contains 38 papers, the majority in English with summaries in French and German.

A quarter century of teaching food technology. Bernard E. Proctor and Samuel A. Goldblith. Cambridge, Mass., Massachusetts Institute of Technology, Department of Food Technology, 1958. 22 p. processed. pap. apply. Indicates gradual change in program offered from 1934 to 1958.

Chemical and Nutritional Aspects

Biochemical engineering; unit processes in fermentation. R. Steel, ed. New York, Macmillan, 1958. 328 p. $7.50. An expanded version of lectures given by experts in the field in 1957 at the Manchester College of Science and Technology.

Cholesterol; chemistry, biochemistry and pathology. Robert P. Cook. New York, Academic Press, 1958. 556 p. $15.00.

General cytochemical methods, v. 1. J. F. Daniell. New York, Academic Press, 1958. 483 p. $12.50.

Influence of temperature on vitamin levels in bovine blood. R. Singh and C. P. Merilan. Columbia, Mo., 1957. 40 p. (Missouri Agricultural Experiment Station. Research bulletin 639.) pap. apply. One of a series on Environmental physiology and shelter engineering with special reference to domestic animals.

Metabolism of lipids. British Medical Bulletin, 14, No. 3. Price $3.25. Medical Dept., the British Council, 65 Davies Street, London, W. I.

Metabolism of sulphur compounds. Leslie Young and George A. Maw. New York, John Wiley, 1958. 180 p. (Methuen's monographs on biochemical subjects.) $3.00. Metabolism of sulphur compounds in higher animals and microorganisms.

Economic and Social Aspects

The influence of selected factors on milk consumption in New Orleans. A Ortego and W. H. Alexander. Baton Rouge, La., 1957. 44 p. (Louisiana Agricultural Experiment Station. DAE C 212.) pap. apply.

Livestock and meat statistics, 1957. Washington, U. S. Dept. of Agriculture, 1958. 307 p. (U.S.D.A. Agricultural Marketing Service. Statistical bulletin no. 230.) pap.

Marketing costs and margins for processed cheese. J. K. Little and H. W. Halvorson. Washington, U. S. Department of Agriculture, 1958. 8 p. (U. S. Agricultural Marketing Service. AMS-238.) pap. apply.

Marine Fish Catch of California (1955, 1956). Fish Bull. 105. State of California. Dept. of Fish and Game, Sacramento, California. pap. apply.

Food Acceptance

Changing food habits and research. Emil M. Mrak. Davis, Calif., University of California. Dept. of Food Technology, 1958. 8 p. processed. pap. apply. Paper presented at annual meeting of Dried Fruit Association of California.

Flavor research and food acceptance. Sponsored by Arthur D. Little, Inc. New York, Reinhold Book Division, 1958. 416 p. $10.00. Chapters by a large number of acknowledged leaders in the field. Reviewed in this issue.

Bibliographies

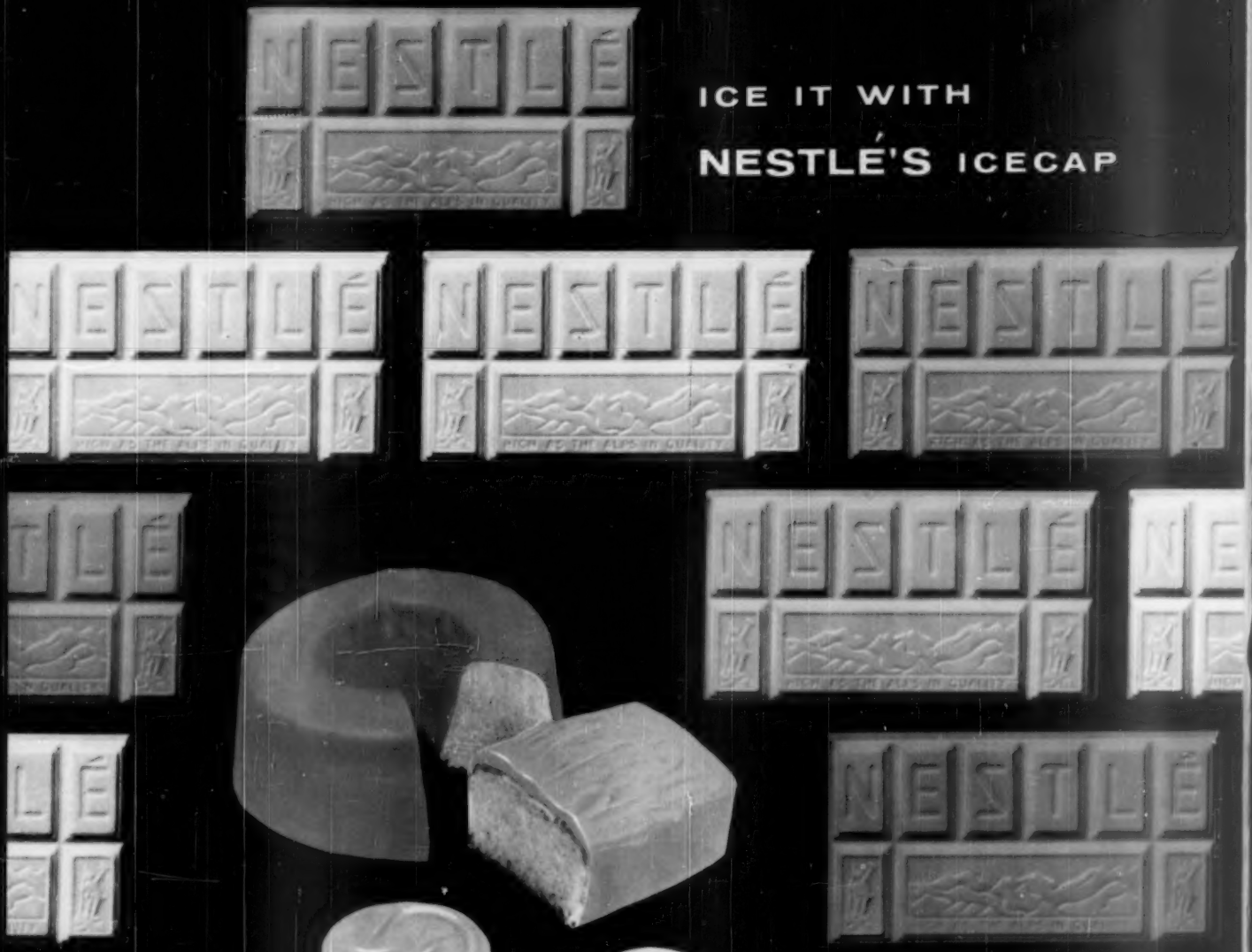
Bibliography of organic acids in higher plants. M. L. Buch. Washington, U. S. Dept. of Agriculture, 1957. 136 p. (U. S. Agricultural Research Service. ARS-73-18.) pap. apply.

Food from Algae, a review of the literature. John Lavery and Robert G. Tischer. Chicago, 1958. 31 p. processed. (U. S. Quartermaster Food and Container Institute for the Armed Forces. Library Branch. Library bulletin 1.) pap. apply.

Miscellaneous

Accessibility of Russian scientific and technical literature in Western nations. Viebeke Ammundsen; condensed translation from the Danish by Julian F. Smith. Washington, 1958. 12 p. processed. (U. S. National Bureau of Standards. Report 6115.) pap. apply. Original article

[1] Material for this list should be sent to Dr. James G. Hodgson, Chief, Library Branch, Quartermaster Food and Container Institute for the Armed Forces, 1819 W. Pershing Road, Chicago 9, Illinois.



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was in *Ingeniören*, 67: 317–26, May 15, 1958.

Feeding men during space flight. Chicago, 1958. 36 p. (Institute of Food Technologists. Studies in food science and technology, 2.) pap. $1.00. Reprinted from *Food Technology*, v. 12, no. 10, September 1958.

The principles of science; a treatise on logic and scientific method. W. S. Jevons. New York, Dover Publications, 1958. 839 p. pap. $2.98. A reissue, with a new introduction, of a famous old work that has greatly influenced scientific thinking.

ABSTRACTS

—Compiled by H. A. Campbell

ANALYTICAL METHODS

The separation of complex lipide mixtures by the use of silicic acid chromatography.

HIRSCH, J. AND AHRENS, E. H. (Rockefeller Inst., New York City). *J. Biol. Chem. 233*, 311–20 (1958).

A method is described for the sepn. of complex lipide mixts. into chemical classes by elution from a single column of silicic acid. The method has been tested by the sepn. of synthetic mixts. and the mixt. of lipides found in human plasma. Some of the many possible applications are illustrated.

Proof of the accuracy of pH measurements with the glass electrode in the system methanol-water.

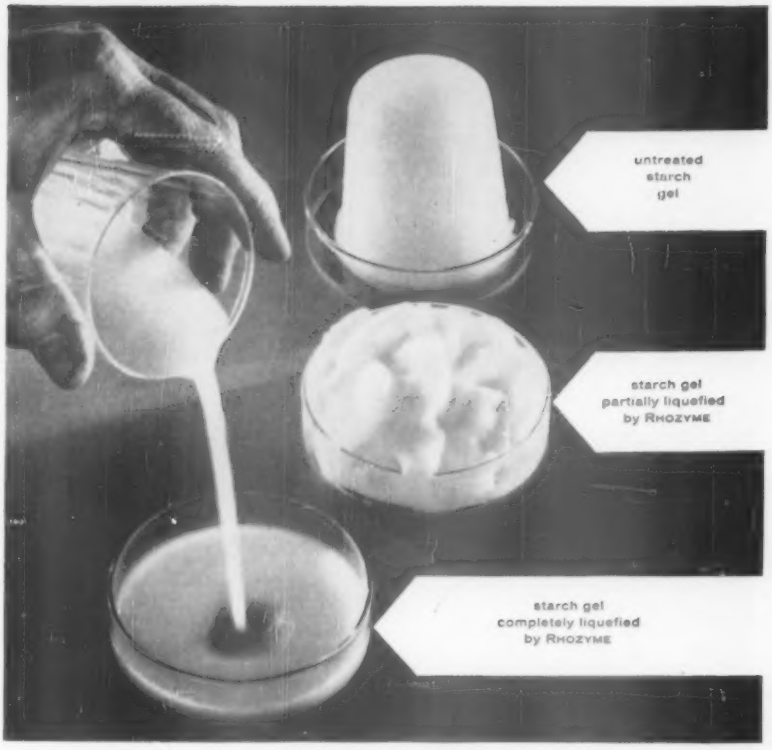
BACARELLA, A. L., GRUNWALD, E., MARSHALL, H. P. AND PURLEE, E. L. (Chem. Dept., Florida State Univ., Tallahassee). *J. Phys. Chem. 62*, 856–7 (1958).

Previous claims of discrepancies between pKa values obtained potentiometrically with the glass electrode and conductometrically for acetic acid in methanol-water mixts. are shown to be incorrect. The 2 methods yield results that are identical with exptl. error, thus establishing the accuracy of pH measurements with the glass electrode in solvent compns. up to 95% (wt.) methanol. Experimental conditions which must be satisfied in order to obtain accurate results with the glass electrode are reviewed.

Ion exchange resins as indicators.

MILLER, W. E. (Dept. of Chem., The City Coll., New York City). *Anal. Chem. 30*, 1462–4 (1958).

Acid-base indicator forms of ion exchange resins will act as indicators and may be used in conventional titrations. Such indicators are in a phase separate from the solution whose pH they indicate. Data on acid-base titrations with thymol blue, bromocresol green, and



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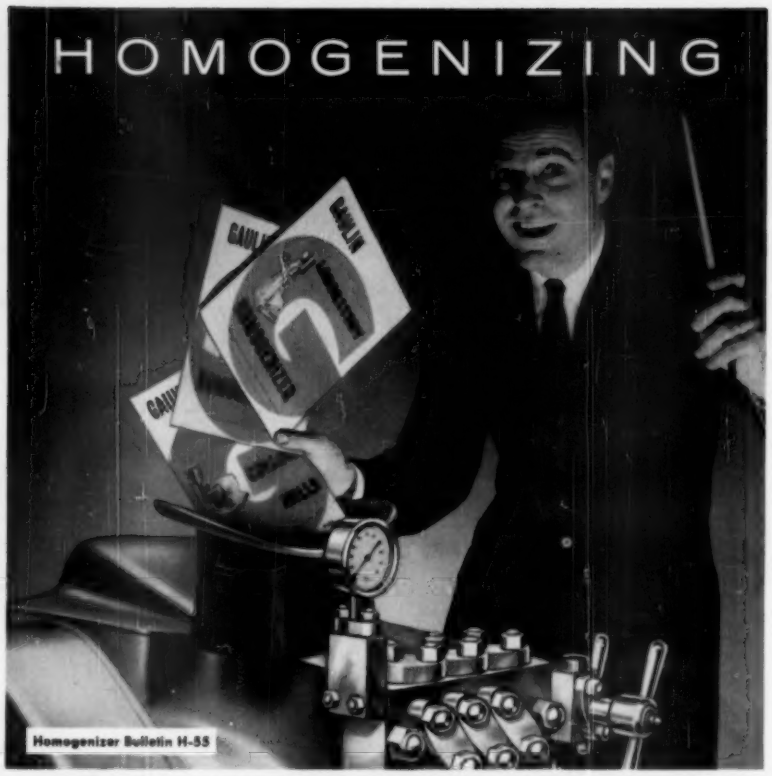

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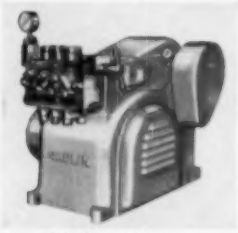

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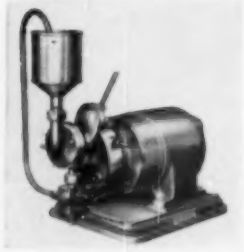

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BIOLOGICAL SCIENCES

Biochemistry

Specificity of peptides.

Woolley, D. W. and Merrifield, R. B *Science 128*, 238–40 (1958).

The data now at hand show that specificity among biologically active peptides is probably not as exquisite as might have been deduced from experiences with some of the water-sol. vitamins. It is plain that a given biological effect can be evoked by peptides which differ considerably. It is likewise plain that the effect cannot be evoked by a no. of other peptides. There is apparently some specificity, but more is involved than that incorporated in the classical view.

Measurement of protein turnover in rat liver.

Swick, R. (Argonne Natl. Lab., Lemont, Ill.). *J. Biol. Chem. 231*, 751–63 (1958).

The rate of renewal of liver proteins has been estd. from the measurement of the incorporation of $C^{14}O_2$ into the guanidine group of arginine in adult rats continuously exposed to isotope for periods of 1 to 8 days. The calcd. half lives of liver proteins ranged from 1.8 to 3.8 days, depending upon the duration of the exposure. The similarity of estimates made from the incorporation of isotopic glycine in the same animals leads to the conclusion that the rate of incorporation of either glycine or the guanidine moiety of arginine represents the rate of protein renewal.

Photosynthesis of amino acids.

Deschreider, A. R. (Ministry of Econ. Affairs, Brussels, Belgium). *Nature 182*, 528 (1958).

It was concluded that ultra-violet, at a wave-length of 2537 A., is able to synthesize amino acids from mixts., contg. either a satd. dicarboxylic acid such as succinic acid, an unsatd. dicarboxylic acid such as maleic acid or a monocarboxylic acid such as propionic acid with carbonate or thiocyanate and ammonia. The amino acids formed were those contg. 4, 3, and 2 carbon atoms.

Sex difference in induction of periportal fatty liver by methionine deficiency in the rat.

Sidransky, H. and Farber, E. (Dept. of Physiol. and Biochem., Tulane Univ. School of Med., New Orleans, La.). *Proc. Soc. Exptl. Biol. Med. 98*, 293–7 (1958).

Force-feeding of purified choline-contg. diets devoid of methionine for 3–6 days induced fatty livers in adult female rats, but not in adult male rats.

Excess lipid accumulates in the periportal region of the liver lobule. Force-feeding of threonine-devoid diet for 3 days to adult rats also induces periportal fatty liver but without a sex difference. Since choline does not protect liver against the effects of methionine deficiency, it appears that methionine must play some role in regulation of lipid content of liver aside from its contribution of methyl groups for synthesis of choline.

A study of the reaction of the disulfide groups of bovine serum albumin during heat denaturation.

STEINHAUF, L. K. AND DANDLIKER, W. B. (Dept. of Biochem., Univ. of Washington). *J. Am. Chem. Soc. 80*, 3833–5 (1958).

The polymerization of heat denatured bovine serum albumin has been followed by means of soly. in 83% acetic acid. The monomer and lower polymers are sol. in this solvent while the higher polymers are not. The effects of pH changes and sulfhydryl reagents indicate that the polymerization proceeds by means of a disulfide exchange with a sulfhydryl intermediate. A sample of a mixt. of monomer and dimer was obtained in water-sol. form by the lyophilization of an 83% acetic acid soln. This recovered protein had slightly higher intrinsic viscosity than the native protein, slightly lower optical rotation and a more rapid rate of digestion by trypsin.

Solution properties of branched dextrans.

GRANATH, K. A. (Univ. of Uppsala, Sweden). *J. Colloid Sci. 13*, 308–28 (1958).

In this discussion an attempt has been made to correlate the hydrodynamic properties of some dextrans as a function of their degree of branching. The effects of possible variations in the distribution of the branches along the chain and in the distribution of their lengths have not been considered here.

A universal molecule of living matter.

KAMEN, M. D. (Brandeis Univ., Waltham, Mass.). *Sci. American 199*, 77–82 (Aug. 1958).

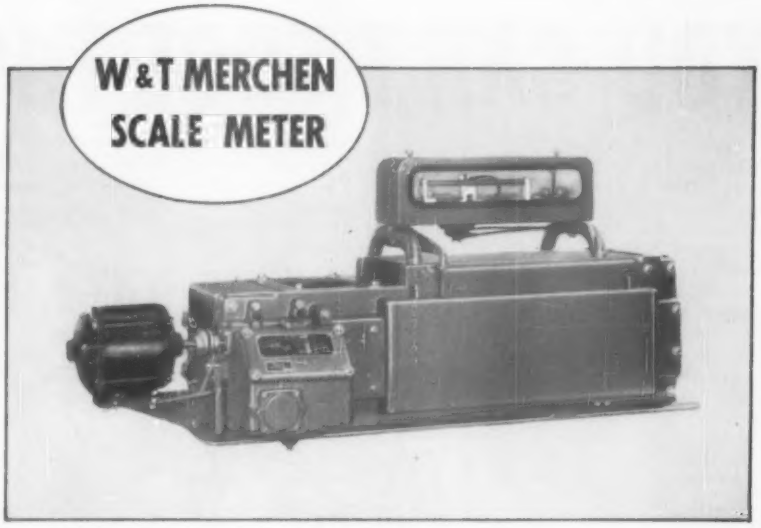
Small modifications in the basic configuration of the tetrapyrrole ring permit this structure to perform an amazing variety of functions in all living organisms from bacteria to man. The ring occurs in the hemoglobin of blood, chlorophyll of plants and various enzymes involved in metabolism.

Microbiology

Isolation of salmonellae from food samples. II. The effect of added food samples upon the performance of enrichment broths.

SILLIKER, J. H. AND TAYLOR, W. I. (Research Labs., Swift and Co., Chicago, Ill.). *Appl. Microbiol. 6*, 228–32 (1958).

Neither overwhelming numbers of coliform organisms nor an unfavorable im-



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balance in the ratio of coliforms to salmonellae materially affected the selectivity of selenite of tetrathionate enrichment broths for salmonellae. The performance of these broths were, however, greatly diminished by the addn. of many kinds of food materials; gelatin and albumen caused the most striking diminution of salmonella recoveries; egg yolk, the least. Separation of the bacteria from the sol. food material by centrifugation proved to be an effective means of restoring the function of enrichment media.

Dwarf colony mutants of salmonellae.

STOKES, J. L. AND BAYNE, H. G. (Western Regional Research Lab., Albany, Calif.). *J. Bacteriol. 76*, 136–41 (1958).

Dwarf colony mutants have been isolated from 10 normal salmonellae strains by growing the latter in nutrient broth contg. lithium sulfate or sodium selenite. The data suggest that dwarf colony strains of salmonellae are growth-factor-dependent mutants which grow slowly on conventional media because the latter do not contain adequate amts. of the required essential or stimulatory growth factors.

Nutrition

Diet and atherosclerotic disease. II. Animal experimental research.

STAMLER, J. (Cardiovascular Dept., Med. Research Inst., Michael Reese Hosp., Chicago, Ill.). *J. Am. Dietetic Assoc. 34*, 814–18 (1958).

A discussion of the implications of animal exptl. research relating diet and atherosclerotic disease. The author discusses production of atherosclerosis in different species, studies conducted with unsatd. fatty acids, and the relationship of diet to cholesterolemia and atherogenesis.

Serum cholesterol reduction with lecithin.

MORRISON, L. M. (Los Angeles County General Hosp., Calif.). *Geriatrics 13*, 12–20 (1958).

Soybean lecithin was administered under strict control conditions to a series of patients with hypercholesterolemia, who had been treated with low-fat diet and various other cholesterol-lowering agents with unsuccessful results. Effective and statistically significant reduction in serum cholesterol levels occurred in the majority of patients treated by lecithin.

Serum cholesterol in man and the unsaponifiable fraction of corn oil in the diet.

GRANDE, F., ANDERSON, J. T. AND KEYS, A. (Lab. of Physiol. Hygiene, Univ. of Minn., Minneapolis). *Proc. Soc. Exptl. Biol. Med. 98*, 436–40 (1958).

Comparison of corn oil with 4 other oils of the linoleic-oleic acid type consistently indicated that corn oil in the diet produced slightly lower serum cholesterol values than those predicted, on the basis of fatty acid compn. It is concluded that the unsaponifiable matter of 100 g. of corn oil lowers serum cholesterol by between 6 and 12 mg./100 ml.

Effects of the esterification of supplemental cholesterol and sitosterol in the diet.

BEST, M. M. AND DUNCAN, C. H. (Dept. of Med., Univ. of Louisville School of Med., Kentucky). *J. Nutrition 65*, 169–81 (1958).

Serum and liver cholesterol levels of rats were detd. at the end of 14 days' maintenance on the following diets: low cholesterol, 1% cholesterol, and equiv. amts. of cholesteryl acetate, benzoate, palmitate, stearate and oleate. The increment in liver cholesterol was almost entirely in the ester fraction, without regard to whether the cholesterol added to the diet was free or esterified.

Linoleic acid and cholesterol metabolism in the rat. I. The effect of dietary fat and linoleic acid levels on the content and composition of cholesterol esters in liver and plasma.

KLEIN, P. D. (Argonne Natl. Lab., Lemont, Ill.). *Arch. Biochem. Biophys. 76*, 56–64 (1958).

Rats show an increase in plasma cholesterol as the linoleic acid content of the diet is increased. The liver cholesterol esters are increased in fat deficiency, low in normal ranges of dietary fat, and increased again at high levels of linoleic acid. This second increase is specifically related to the polyunsatd. fatty acid content not fat level. Possibilities for the derivation of plasma cholesterol esters from liver cholesterol are discussed.

Bile acid metabolism, dietary fats, and plasma cholesterol levels.

BYERS, S. O. AND FRIEDMAN, M. F. (Mt. Zion Hosp., San Francisco, Calif.). *Proc. Soc. Exptl. Biol. Med. 98*, 523–6 (1958).

Administration of highly unsatd. fats to the rat effected a greater intestinal absorption of cholesterol than similar administration of satd. fats. Continued ingestion of highly unsatd. fat produced a fall in plasma cholesterol accompanied by marked increase in excretion of both cholesterol and bile acid in the bile.

Tryptophan metabolism in normal and diabetic subjects.

WISEMAN, M. H., KALANT, N. AND HOFFMAN, M. M. (McGill Univ., Montreal, Can.). *J. Lab. Clin. Med. 52*, 27–33 (1958).

A procedure has been described which permits an evaluation of tryptophan metabolism suitable for clinical purposes; it is based on a measurement of the excretion of various tryptophan metabolites following ingestion of trptophan. Diabetic and nondiabetic subjects have been studied by this means to det. the effect of tryptophan on glycemia. Diabetic subjects were found to excrete a subnormal proportion of the administered load in the form of tryptophan, kynurenine, anthranilic acid, and xanthuremic acid, but normal amts. of 5-hydroxyindoleacetic acid. Tryptophan effected a minor decrease in blood sugar concns. in diabetic but not in normal individuals.

Hematologic manifestations of lysine deficiency in swine.

ATHENS, J. W., CARTWRIGHT, G. E. AND WINTROBE, M. M. (Dept. of Med., Univ. of Utah Coll. of Med., Salt Lake City). *Proc. Soc. Exptl. Biol. Med. 97*, 909–12 (1958).

Twenty-three swine were fed a diet deficient in lysine. In addn. 5 swine were given hexahomoserine (6-hydroxy-DL-norleucine), a lysine antagonist. All animals developed a normocytic, normochromic anemia, which was accompanied by hypoalbuminemia and hypocupremia. The anemia responded rapidly to the administration of lysine. Lysine is apparently necessary for normal erythropoesis in the swine.

Digestibility of uniformly labelled carbon-14 soybean cellulose in the rat.

CONRAD, H. E., WATTS, W., *et al.* (Mead Johnson and Co., Evansville, Ind.). *Science 127*, 1293 (1958).

Uniformly labelled C^{14} cellulose prepd. from defatted C^{14}-labelled soybean meal was fed to rats. The urine, feces and expired CO_2 were collected and analyzed. The data indicate that a large proportion of the ingested cellulose is converted in the gastrointestinal tract to a form which the rat absorbs and metabolizes readily. The data show that only half of the C^{14} fed the rat is excreted in the feces, the rest being found distributed in the expired CO_2, carcass, and urine.

Study of 1-phenyl-2-aminopropane alginate (Levonor), new anorectic.

GADEK, R. J., FELDMAN, H. S. AND LUCARIELLO, R. J. (Dept. of Med. and Nutrition Clinic, New York Med. Coll.). *J. Am. Med. Assoc. 167*, 433–7 (1958).

A new drug, 1-phenyl-2-aminopropane alginate (Levonor), was administered, in conjunction with diet, to 80 overwt. patients. The average wt. loss was 2 lb. (0.9 kg.) per week. While 1-phenyl-2-aminopropane alginate appears at least

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as effective as other appetite suppressants, it seems to be better tolerated and allows for more freedom in adjusting dosage. However, the drug is of no value for the depressed obese patient or in cases where psychic stimulation is indicated.

Toxicology

Toxicological studies on sesamol.

AMBROSE, A. M., COX, A. J. AND DEEDS, F. (Western Utilization Research and Devel. Div., U. S. Dept. of Agr., Albany, Calif.). *J. Agr. Food Chem. 6*, 600–6 (1958).

Sesamol, a constituent of sesame oil, possesses antioxidant properties, and is at least partly responsible for the stability of this oil. It can now be produced commercially and is a potentially useful antioxidant. Investigations show that it is nonirritant to the skin and does not cause skin sensitization. Over a long period of time, feeding of twice recrystallized sesamol to rats had no growth, mortality, or blood morphology effects.

Metabolic and glucosuria studies on naringin and phloridzin.

BOOTH, A. N., JONES, F. T. AND DEUCDS, F. (Western Utilization and Research Devel. Div., Albany, Calif.). *J. Biol. Chem. 233*, 280–2 (1958).

Naringin and phloridzin and their respective aglycons were administered to rats either by stomach tube or subcutaneously. It was only when phloridzin was injected that glucosuria was produced. All 4 of these compds. gave rise to the same degradation products in the urine, including *p*-hydroxyphenylpropionic acid, as well as small amts. of *p*-coumaric acid and the ethereal sulfate of *p*-hydroxybenzoic acid. Also in each case the aglycon and the aglycon conjugated with glucuronic acid were recognized in the urine.

Nature of the carcinogenic substance in egg-yolks.

HRADEC, J. (Dept. of Biochem., Oncological Inst., Prague, Poland). *Nature 182*, 52–3 (1958).

A high incidence of malignant tumors was recently reported in mice fed egg-yolks, and the presence of a growth-promoting factor in the yolks has been thought to be responsible for this effect. Application of the procedures used in the isolation of tumor-enhancing factor from animal tissues to the unsaponifiable portion of yolks gave a considerable quantity of a fluorescent substance, the chromatographic behavior and the absorption spectra of which were identical with those given by material from rat tissues. These facts strongly support the concept that the growth-promoting factor in egg-yolk and the tumor-enhancing factor are identical.

ENGINEERING RESEARCH

Scale-up relationships for heat transfer in Votators.

SKELLAND, A. H. (Univ. of Birmingham, Engl.). *Brit. Chem. Eng. 3*, 325–7 (1958).

Relationships useful to designers dealing with various aspects of heat transfer in these widely-used machines are presented.

Some experiments on orifice sprays.

RANZ, W. E. (Pennsylvania State Univ., University Park). *Can. J. Chem. Eng. 36*, 175–81 (1958).

New approaches to studies of spray systems were demonstrated by a series of expts. involving liquid jets spraying in liquids. Attention was focused on those conditions where the stresses causing break-up arose from the inertia of the surroundings and where the induced motion of the surroundings controlled the characteristics of the spray zone in front of the orifice. Experiments and analysis involved principle of balanced stresses, dispersion angle, motion of induced phase, development of spray zone, and drop size.

FOOD AND FOOD TECHNOLOGY

Dehydration

Process of comminuting and dehydrating foods.

RIVOCHE, E. J. U. S. 2,844,476. July 22, 1958.

Large pieces of frozen food are brought into abrasive contact with a hygroscopic food powder. Continuous agitation removes layer after layer of dehydrated particles from the surface of the frozen pieces.

Fats and Oils

A characterization of volatile carbonyl compounds isolated from meat fat subjected to gamma radiation.

WITTING, L. A. AND SCHWEIGERT, B. S. (Am. Meat Inst., Chicago, Ill.). *J. Am. Oil Chemists' Soc. 35*, 413–16 (1958).

The volatile carbonyl compds. from irradiated lard were isolated and characterized qualitatively and quantitatively as the 2,4-dinitrophenylhydrazones. Propional, butanal, pentanal, hexanal, nonanal, decanal, acrolein, crotonal, and 2,4-undecadienal were identified by paper chromatography and spectrophometric analysis.

Process for preparing fluid shortening.

LANTZ, C. W., COCHRAN, W. M. AND LUTZ, R. E. Assignors to the Glidden Co. U. S. 2,846,312. Aug. 5, 1958.

A method for converting plasticizable shortening in a homogeneous liquid condition to a stable fluid condition. The chilled shortening is stirred for 48 hrs. until fine crystals of the normally-solid glycerides are dispersed uniformly throughout the mass.

Fruits and Vegetables

Studies on the heat inactivation of sweet corn peroxidase and the relationship between peroxidase activity and quality of the frozen product.

VETTER, J. L. (Univ. of Illinois, Urbana). *Dissertation Abstr. 18*, 2106 (1958).

A spectrophotometric procedure involving the catalytic oxidation of *O*-phenylenediamine by the enzyme in the presence of H_2O_2 was developed for the quant. detn. of peroxidase activity. There are indications that peroxidase may be assocd. with off flavor development in inadequately processed frozen corn.

Nutrients in cooked frozen vegetables.

TEPLY, L. J. AND DERSE, P. H. (Wisconsin Alumni Research Foundation, Madison). *J. Am. Dietetic Assoc. 34*, 836–40 (1958).

Twenty-four vegetable products were subjected to cooking procedures which involved the use of minimal amts. of water and cooking to subjectively detd. "optimum flavor doneness." Little leaching of nutrients into the liquor was noted except for 10–25% of the sodium in most products and 15–25% of all the vitamins except β-carotene in turnip greens. Considering over-all (solids plus liquor) recovery, there was essentially complete retention of thiamine, riboflavin, and niacin. Many products retained 90% of vitamin C.

Gelatin and Collagen

Degradation of collagen by heat.

CASSEL, J. M. (Natl. Bureau of Standards, Washington, D. C.). *J. Am. Leather Chemists' Assoc. 53*, 507–24 (1958).

Purified steerhide collagen heated at temps. ranging from 125° to 170° C. in vacuum, air, and oxygen for periods of 3 days shows reduced capacity to adsorb water vapor and increased soly. in water. Small changes are apparent in the infrared spectra of the most severely degraded materials. Losses in the amts. of a number of amino acids as the temp. of heating is increased are shown by quant. paper-chromatographic analysis. In particular, methionine, serine, threonine, and tyrosine are affected.

Milk and Milk Products

A method for manufacturing a high-nitrogen-low-lactose product from whey.

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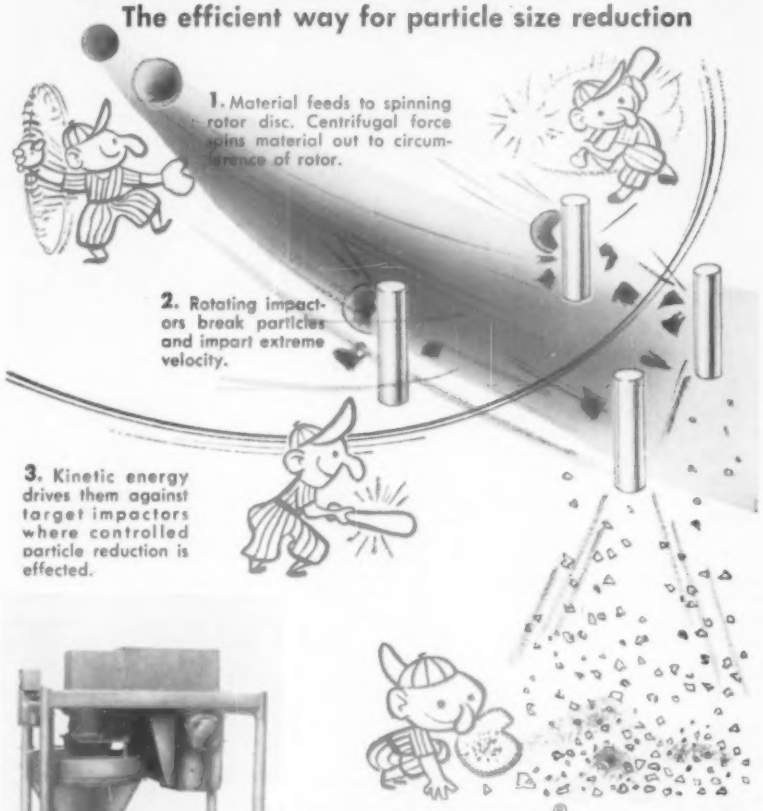
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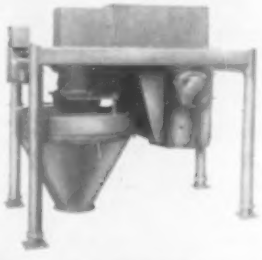

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ARNOTT, D. R., PATTON, S. AND KESLER, E. M. (Dept. of Dairy Sci., Penn. State Univ., University Park). *J. Dairy Sci. 41*, 931–41 (1958).

Total N of cheddar cheese whey is raised from 0.15 to 0.80% by fermentation with *Lactobacillus bulgaricus* followed by treatment with anhydrous NH_3 to neutralize the lactic acid formed. Treated whey is then concd. to a syrup.

Starch

The enzymic degradation of 'raw' starch granules.

TURVEY, J. R. AND HUGHES, R. C. (Dept. of Chem., Univ. Coll. of North Wales, Bangor). *Biochem. J. 69*, 4P (1958).

By pptn. of cold aq. exts. of sprouted potatoes with $(NH_4)_2SO_4$, protein fractions which slowly attack potato starch grains were obtained. The presence of an activator, as well as an inhibitor of the reaction has been demonstrated in the potato juice. It was found that inorg. phosphate activates the raw starch factor and that glucose-1-phosphate is one of the main products of degradation. Further tests have indicated that phosphorylase prepd. from potato attacks starch grains in the presence of mineral phosphate but not in its absence. There is thus indication that the 'raw starch factor' is phosphorylase.

Miscellaneous

Literature problems in organic chemistry.

ELLIS, G. P. (Benger Labs., Cheshire, Eng.). *Research* (London) *11*, 276–8 (1958).

The aim of the present article is to assist postgraduate students and others who have little or no experience to make use of today's vast org. chem. literature in the most economical way. It is complementary to an earlier article on the literature of phys. and inorg. chemistry which contains much that is common to both branches of chemistry.

What is basic research?

SELYE, H. *Metabolism 7*, 387–97 (1958).

The author develops a definition and criteria of good basic research and of the distinction between development and discovery, with interesting illustrations from the history of science. Emphasis is placed on the importance of strength of intellect for survival in war and well-being in peace.

ORGANIC CHEMISTRY

Hydrogen ⟶ deuterium exchange reaction in α-keratin.

FRASER, D. B. AND MACRAE, T. P. (Wool Textile Research Labs., Melbourne, Australia). *J. Chem. Phys. 28*, 1120–5 (1958).

A quant. study of the hydrogen ⟶ deuterium exchange reaction in α-keratin by means of infrared spectra showed that after 50 hrs. at 30° C. about 30% of the peptide linkages had not reacted. Observations between 50 and 1000 hrs. failed to detect any further reaction but elevation of pD or temp. caused addnl. exchange. Evidence is presented which suggests that the unreactive peptide linkages occur in the organized regions of the structure (microfibrils) and that complete exchange of the replaceable hydrogen atoms in the sidechains takes place.

RADIOCHEMICAL TECHNOLOGY

Radiolysis of aqueous solutions of glycine.

WEEKS, B. M. AND GARRISON, W. M. (Univ. of California Radiation Lab., Berkeley). *Radiation Research 9*, 291–304 (1958).

It is proposed that the indirect action of radiation on glycine in oxygen-free solution results in formation of the free-radical intermediates CH_2COOH and $NH_2CHCOOH$. Although most of these ultimately yield acetic acid and glyoxylic acid, resp., it is concluded that some undergo radical-radical reaction to yield succinic acid, aspartic acid, and diaminosuccinic acid. Effects of oxygen, glycine concn., and pH are discussed.

STATISTICS

Power function charts for specification of sample size in analysis of variance.

FELDT, L. S. AND MAHMOUD, M. W. (State Univ. of Iowa, Iowa City). *Psychometrika 23*, 201–9 (1958).

The specification of sample size is an important aspect of the planning of every expt. When the investigator intends to use the techniques of analysis of variance in the study of treatments effects, he should, in specifying sample size, take into consideration the power of the *F* tests which will be made. The charts presented in this paper make possible a simple and direct estimate of the sample size required for *F* tests of specified power.

MEMORANDA

The Canadian Institute of Food Technology is holding its Second National Conference in Toronto in 1959. The dates are Thursday and Friday—June 11 and 12, and the conference will be held in the greatly enlarged Royal York Hotel. Mark these dates on your calendar of important events and plan now to attend.

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PERSONNEL

Minneapolis-Honeywell Regulator Company has appointed **William S. Taylor,** IFT member, as market manager of food industry instrumentation for its Brown Instruments Division. Taylor has been with the automatic control firm since 1956 as an application engineer. He was graduated from Pennsylvania State University in 1943 in electrical engineering.

W. S. Taylor

W. J. Mutschler

W. J. Mutschler, long prominent in IFT affairs, has been appointed general manager of production engineering for the Metal Division of Continental Can Company. Formerly general manager of cannery equipment service, Mr. Mutschler has been with Continental since 1936 when he joined the company as a chemical engineer.

C. W. Kaufman

Charles W. Kaufman, director of research and development for National Dairy Products Corporation and formerly vice-president of the Packaging Institute, was elected president at the Institute's 20th Annual National Packaging Forum in Chicago on October 14th.

The American Management Association has elected **Dr. Roger H. Lueck,** IFT member, vice president for research, American Can Company, as vice president in charge of its research and development division, it was announced here following the Association's annual board meeting. Dr. Lueck will head the division's voluntary planning council of 23 authorities in the research and development field, the Association said. The group provides guidance to the Association staff in planning meetings held by the division.

EXPANSION NEWS

E. K. Scheiter, President, A. E. Staley Manufacturing Co., left, receives a jar of Hip-O-Lite Marshmallow Creme from F. W. Apperson, Staley's Grocery Products manager. The Company announced purchase of The Hipolite Company and moving of packaging facilities from St. Louis to Decatur.

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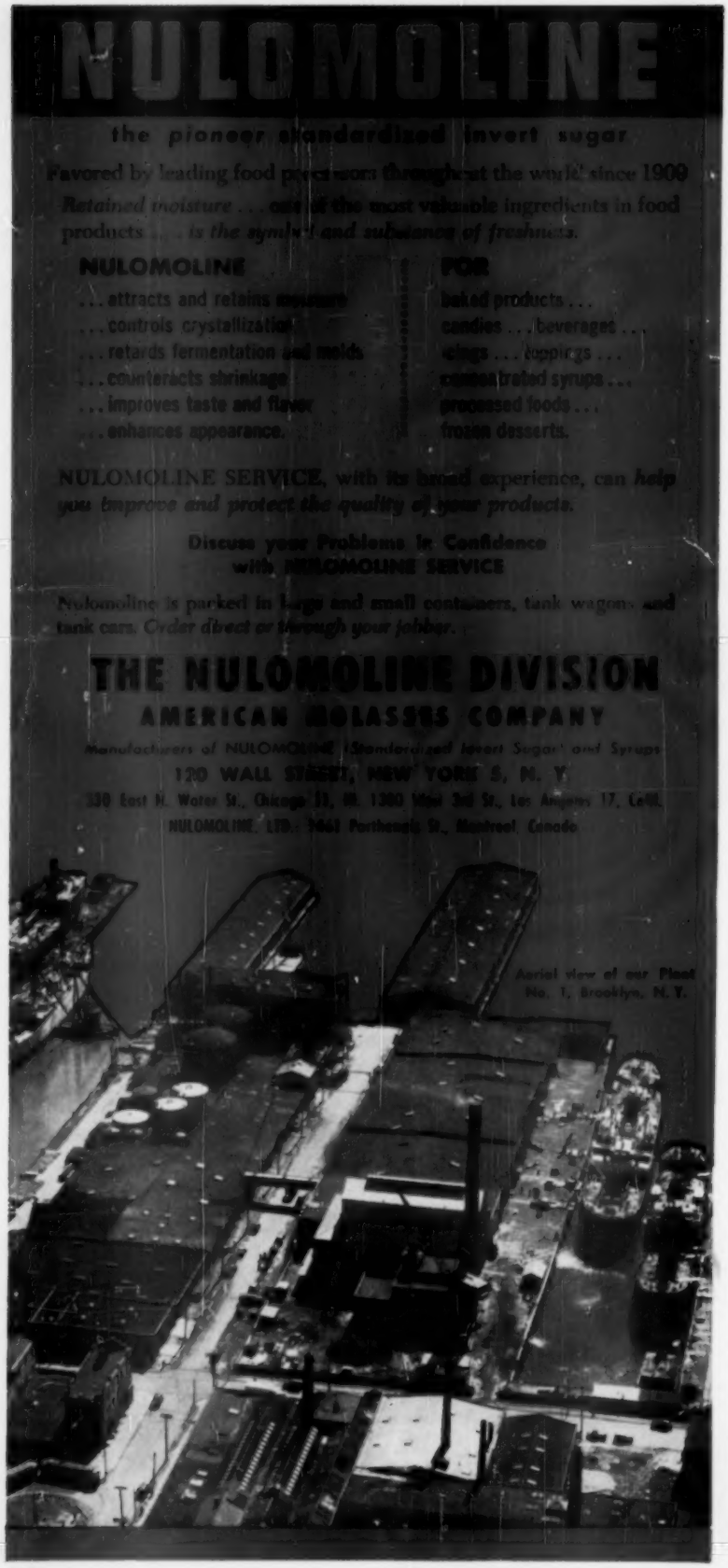
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A workman at Meili and Worthington, Inc., of Hatboro, Pa., is putting the finishing touches on a redesigned disintegrator. This new item is made of stainless steel supplied by Allegheny Ludlum Steel Corporation. The disintegrator is called a "Pagar," and can consume 300-pounds of garbage, paper or other refuse per hour. The end product becomes a valuable organic soil conditioner, which is odorless, insect and rodent proof.

COMMENT

The H. J. Heinz Company was the host at an international scientific symposium, "Advances in Human Nutrition", in Pittsburgh on October 13-14th. This event took place on the occasion of the dedication of the new multimillion dollar International Heinz Research Center and in celebration of the 90th anniversary of the firm.

Recognized leaders in the fields of nutrition, medicine, and public health—both from the United States and abroad—discussed the latest advances in clinical nutrition

research and in the knowledge of nutrition and its bearing on human health. Dr. Charles Glen King, internationally known nutrition authority and Executive Director of the Nutrition Foundation, Inc. served as honorary chairman of the symposium.

Of special interest was the portion of the program devoted to the relationship between nutrition and the degenerative diseases of middle and old age—particularly arteriosclerosis and coronary heart disease. Other portions of the program were devoted to the global aspects of malnutrition, basic nutrition research, maternal and child nutrition, and nutritional therapy in children afflicted with inherited metabolic disorders ("biochemical diseases"). A unique feature of the symposium was a panel discussion on nutrition education—both popular and professional—conducted by Dr. Neige Todhunter, President of the American Dietetic Association, and by medical nutritionists, home economists and educators. About 300 top research scientists, and physicians, both from the United States and abroad, attended the symposium. Dr. Milton Eisenhower, President of Johns Hopkins University, addressed the conference on the subject "United States—Latin American Relations."

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What you should know about oxidative deterioration

What is oxidative deterioration?

In fats and in foods containing fats, oxidative deterioration is caused by the reaction of oxygen in the air with the unsaturated portion of the fat molecule. This reaction produces free peroxide radicals which, in turn, appear to trigger a lengthy chain reaction, the result of which is the formation of a variety of aldehydes, ketones and acids. Once started, the breakdown cannot be reversed. In fact, if allowed to continue, it proceeds at an increasing rate.

Why is it important to food processors?

Oxidative deterioration, unless checked, rapidly takes its toll of fat-containing food products in the form of rancidity. Nothing destroys the reputation of a food product so quickly as the pungent, tallowy odor and flavor characteristic of rancidity.

How can you control oxidative deterioration?

Oxidative deterioration can be effectively controlled with antioxidants. Added to oxygen-sensitive fats and fat-containing food products, these chemical compounds step in to check the rancidity-producing chain reaction referred to above. Since the reaction leading to rancidity cannot be reversed, antioxidants can only prevent further deterioration. Hence, it is essential that they be added as early in the processing of the food product involved as possible.

Which antioxidant is best for you?

The principal food-approved antioxidants in use today are butylated hydroxyanisole (BHA), butylated hydroxytoluene (BHT), and propyl gallate. All are available from Eastman, alone or in solution formulations containing various combinations and ratios of BHA, BHT and propyl gallate, with or without a metal chelating agent.

The most effective and economical formulation for use in any given food product depends upon such factors as the food itself, how it is processed, methods of distribution and storage, and types of packaging. Advice and assistance in selecting the best formulation for your specific requirements is available from the Eastman food laboratories.

Where are these antioxidants available?

Marketed under the trade name TENOX, these food-grade antioxidants and the experienced technical service which backs up their proper use are available from Eastman Chemical Products, Inc., subsidiary of Eastman Kodak Company, Kingsport, Tennessee.

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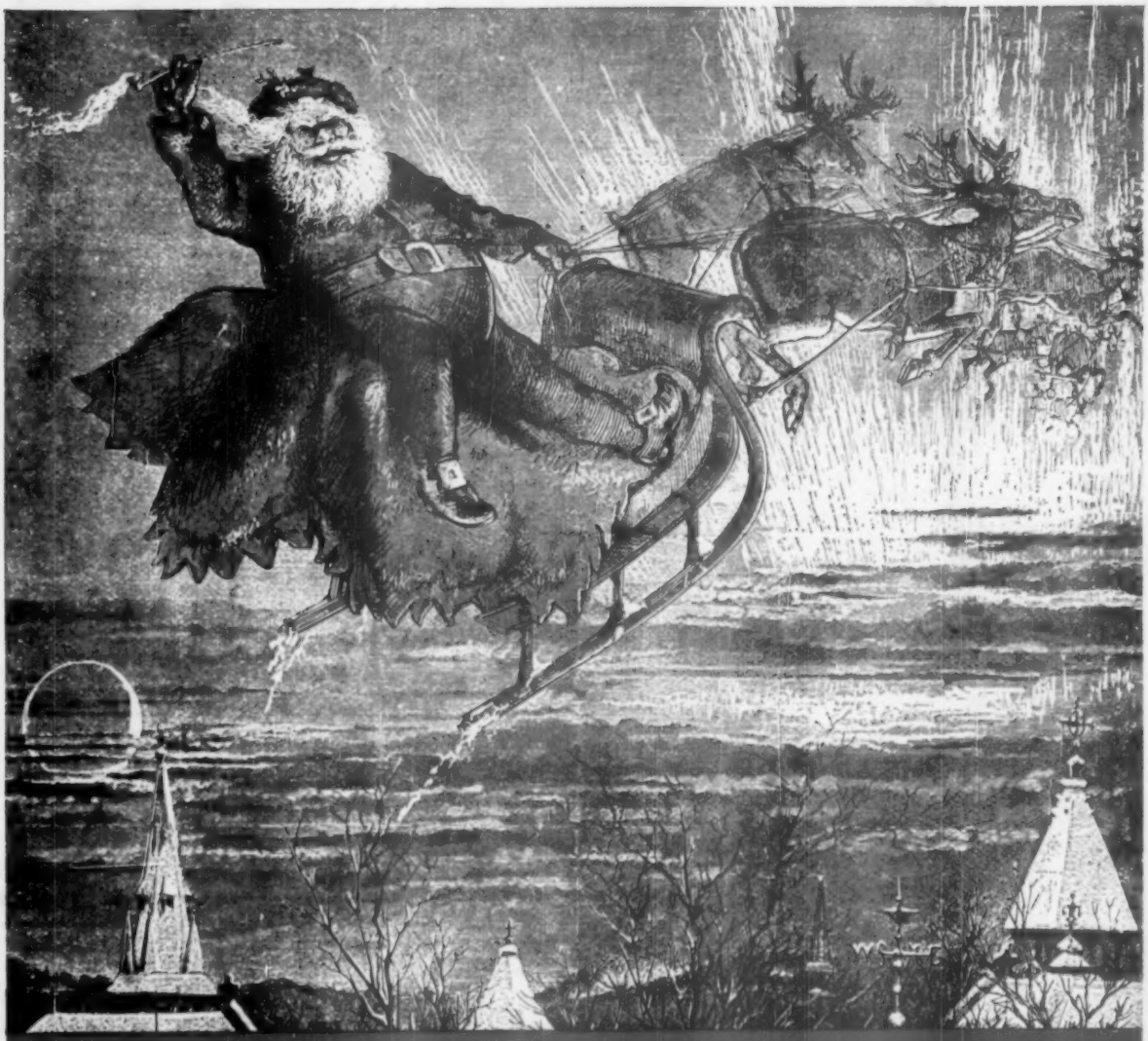

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